SA- None File No. 1-0039

AIRCRAFT ACCIDENT REPORT

OZARK AIR LINES, INC.

DOUGLAS DC-9-15, N974Z

SIOUX CITY AIRPORT

SIOUX CITY, IOWA

DECEMBER 27,1968

ADOPTED: SEPTEMBER 2, 1970

NATIONAL TRANSPORTATION SAFETY BOARD
Bureau 'of Aviation Safety
Washington, D. C. 20591

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SYNOPSIS

At approximately 0711 c.s.t. on December 27, 1968, Ozark Air Lines Flight 982, a Douglas DC-9, crashed while taking off from the Sioux City Airport, Sioux City, Iowa. There were no fatalities. Among the 64 passengers and four crewmembers, 10 passengers were hospitalized with minor injuries and three crewmembers received serious injuries. The aircraft was destroyed in the crash. There was no fire.

Flight 982 began its takeoff on Runway 35 with the fllghtcrew aware that ice was present on the wings. The aircraft lifted off and the landing gear was selected to the up position by the first officer. The captain began turning off the landing and taxi lights. As the landing gear began to retract, the aircraft rolled abruptly and violently to the right to an angle of bank estimated by the flightcrew to have reached 90°. The captain applied additional power and left rudder in an attempt to level the wings. When no immediate response was noted, he then applied left aileron. With the application of left aileron, the right wing came up; however, the roll continued to the left until the left wing contacted the runway. At this point, the captain discontinued the takeoff. He succeeded in leveling the wings prior to final ground contact, approximately 110 feet beyond the departure threshold of Runway 35. The aircraft came to rest in a grove of trees approximately 1,181 feet beyond the departure end of Runway 35.

At 0657 c.s.t., the surface weather observation at Sioux City was reported as 800 feet overcast with visibility 3 miles. Fog was present and a light, freezing drizzle was falling. The temperature was 22°F., the dew point was 20°F., and the wind was from 360° at a velocity of 10 knots. At 0714 c.s.t., the only changesreported were that the ceiling had become 700 feet overcast and the wind had shifted to 20° at 13 knots.

The Safety Board determines that the probable cause of this accident was a stall near the upper limits of ground effect, with subsequent loss of control as a result of the aerodynamic and weight penalties of airfoil icing. The flightcrew failed to have the airfoil ice removed prior to the attempted takeoff from Sioux City. The Board also finds that the crew selected an improper takeoff thrust for the existing gross weight condition of the aircraft.

As a result of the investigation of this accident, the Board forwarded three recommendations to the Federal Aviation Administration reemphasizing a previous Board recommendation that flight crewmembers wear shoulder harnesses during all takeoffs and landings, that the security and attachment points of the forward stewardess seat be strengthened in order to reduce the possibility of stewardess injury, and that any potential injurious environmental hazard resulting from protruding fixtures on equipment in the area of this seat be minimized by relocation or protective padding with high energy absorption material.

1. INVESTIGATION

11 History of Flight

Ozark Air Lines Flight 982, was a regularly scheduled passenger flight from Sioux Falls, South Dakota, to O'Hare International Airport, Chicago, Illinois, with a scheduled enroute stop at Sioux City, Iowa.

The flight arrived at Sioux Falls as Ozark Flight 985 at approximately 0015 1/ on the morning of the accident. Following a rest, the same flightcrew originated Ozark Flight 982 out of Sioux Falls. departing Sioux Falls at 0625, after being cleared to Sioux City, Iowa, to fly at an altitude of 11,000 feet. The flight arrived at the ramp at Sioux City at 0658, after making an Instrument Landing System (ILS) approach to the Sioux City Airport.

(a) The Events According to the Crew

The ILS approach to Sioux City was uneventful with all systems performing properly. Visual contact with the ground was established when the aircraft came out of the clouds at 700 feet above the ground. After a routine landing, the flight taxied to the ramp where it remained for approximately 10 minutes. The crew was aware that a "small" accumulation of ice was present on the aircraft, but the captain did not consider it significant.

After receiving clearance, the flight departed the ramp for takeoff on Runway 35. The engine anti-ice and fuel heater system were turned on while taxiing. The takeoff run was accomplished and the aircraft lifted off and began its climb. The captain called for the landing gear to be raised and began to turn off the landing and taxi lights.

As the landing gear began to retract, according to the captain, the right wing "suddenly and violently dropped to what seemed to be a 90° angle of bank." The captain attempted to raise the wing with rudder and added power, but to no avail. Upon application of aileron control, the right wing came up; however, the aircraft continued to roll to the left to an angle of about 45° and the captain felt the left wing contact the runway. At this point, the attempted flight was discontinued.

The wings were leveled and the power reduced just before ground contact. The aircraft slid straight ahead for a period of time, then swerved several times while striking trees and various objects. The aircraft came to rest after a violent swerve to the right.

1/ All times herein are central standard, based on the 24-hour clock.

After the aircraft came to a stop, the captain attempted to get out of his seat to perform emergency procedures but could not do so because his back had been injured during the final swerve of the aircraft. The first officer also received back injuries; however, these did not preclude him from performing his duties. He placed both fuel valve controls in the closed position then left his seat and, after releasing the captain's seat belt, proceeded to the cabin to assist in passenger evacuation. The stewardess stationed in the forward cabin had been unsuccessful in her attempts to open the forward airstair door and was at that time attempting to open the galley exit. The first officer, with the assistance of a passenger, opened the tree-blocked forward airstair door a sufficient amount to permit evacuation. He then assisted the stewardess at the galley exit but that door could not be opened. Finally, he assisted with the evacuation which was in progress at the window exits over the wings.

Upon completion of passenger evacuation, the first officer was joined by the captain and they checked the cabin for any remaining passengers. They then returned *to* the cockpit and attempted to shut down the left engine which had continued to run, but were unable to do so. The left engine continued running for 2 more hours until a mechanic came from Sioux Falls by automobile to shut it down. After several attempts, the mechanic was able to pull the firewall shutoff handle and the engine stopped about 1 minute later.

According to the captain, coupled speed command 2/ was being used on takeoff, and all indications were normal until the right wing dropped. No stall warning was received.

(b) Events According to Ground Handling Personnel

Fueling of Ozark Flights at Sioux City was performed by a contract with a local operator. Two employees of the operator fueled Flight 982 on the morning of the accident. Neither saw the accident, but both saw ice on the wings of the aircraft while they were fueling it. One employee said that the ice on the wings had sharp points sticking out as much as an inch, and extended back under the wings for 6 to 8 inches and was about one-sixteenth of an inch thick. He informed the ramp agent of this condition, who in turn reported the ice to the captain of the flight. The employee stated further that deicing procedures were not carried out, and that freezing rain was falling while they were fueling.

2/ Coupled speed command: A takeoff and go-around mode selection which provides speed command attitude information (SCAT), which is displayed on the attitude indicator by the positioning of command bars. By adjusting the aircraft attitude to these bars, a safe margin above stall buffet is assured.

The other man refueling the aircraft noticed rime ice on the leading edge of the wings and said that the thickness of the ice was about one-half of an inch at the thickest part and extended around the curve of the leading edge for 6 to 8 inches. There was also some thin ice on the flaps. He said that the Ozark agents were aware of the ice. When the aircraft departed from the ramp, it was still dark and a light drizzle was falling. This employee was a certified flight instructor and had approximately 500 flying hours.

The driver of the refueling truck said that upon arrival at the ramp, the windshield of his truck was relatively clear of ice, but some had accumulated on his windshield by the time the aircraft departed.

One of the station agents associated with the handling of Flight 982 extended the hand rails after the aircraft had parked at the ramp. While doing so, he noticed ice on the wings. Walking up to the wing on the left side, he saw that the whole leading edge of the wing was covered with a layer of rough ice. He then went to assist another agent and informed him of the ice. The second agent advised the captain. The first agent started to get out the deicing equipment, but the second agent advised him that the captain did not want the aircraft deiced,

A third agent said that while he was working on the aircraft, one of the refueling men told him of the ice on the leading edges of the wing. This agent entered the aircraft and advised the captain of the ice and asked if he (the captain) would care to look at it. The captain replied that he did not, and that he would turn on the heat after becoming airborne.

(c) Events According to Control Tower Personnel

Control Tower personnel stated that the takeoff roll was commenced approximately 600 feet down the runway from the threshold, which was a common practice for aircraft using Runway 35. They described the acceleration of Flight 982 during the takeoff roll as seemingly slow. The right wing navigation light was observed to "dip" at a point approximately "three-quarters of the way down the runway" then return to level. The left navigation light then "dipped." Because of distance and darkness, tower personnel Were unable to provide any estimate of altitude attained.

(d) Ground Witnesses

Witnesses in front of the terminal building observed the departure of the aircraft. Their view, however, was somewhat obscured by snowbanks formed by snow removal operations. Five of the witnesses'

statements contain comments relative to slow acceleration during the takeoff roll, saying that the aircraft seemed to be slower than usual or that it did not appear to be gaining speed as fast as it should. One thought that the flight did not get enough speed and was going to try another run before taking off.

Ground witnesses saw one or both wings drop. One person said that he saw the right wing "dip" followed by a more acute dropping of the left wing. He did not think that either wing touched the runway. At this time, he thought the aircraft was about 25 feet *off* the ground. Another witness saw the right wing "tipped" to the right at an angle of about 45° to 60°. Then the plane seemed to straighten out and "tip" more moderately to the left. Still another person saw the left wing low and the right wing high with a lot of yellow flame shooting out of the left engine.

(e) Passengers

The flight from Sioux Falls, South Dakota, was described as uneventful. On boarding the aircraft at Sioux City, one passenger observed the ice on the aircraft. She placed her hand on the side of the aircraft and felt a hard, slick coating of ice. She said that she had a thought about it at the time but dismissed it from her mind because she believed that "they know what they are doing."

The taxi and takeoff roll were also described as uneventful until shortly after lift-off, with the exception that a number of the passengers commented that the acceleration seemed slow.

Twenty-three of the passengers described hearing unusual noises at or shortly after lift-off. All of these passengers were seated in the coach section which is the rear compartment of the cabin. Of these 23 passengers, 18 associated the noises with the engines. The five who did not associate the noises with the engines, associated them with the landing gear retraction, left wing contact with the ground, final ground impact or a combination thereof. The remainder of the passengers either stated they heard no unusual noises or did not comment on unusual noises. The noises were generally described as popping or banging. Three of the passengers described the noises as backfiring, muffled explosions, etc.

Six of the passengers described observing fire or torching coming from one ok the other of the engines.

In general, the passenger descriptions agreed with the crew and ground witness descriptions. They described rotation and lift-off, then dropping of the right wing followed by dropping of the left wing.

Some passengers stated later that the wings were icy when they evacuated the aircraft from the over the wing exits.

The passengers variously estimated the height of the plane above the ground at the time the wings dipped at being from 10 feet to 100 feet. Predominantly, the descriptions were "very little" or 20 to 25 feet.

1.2 Injuries to Persons

Injuries	Crew	Passengers	Others
Fatal	0	0	0
Nonfatal	3	10	0
None	1	54	

In addition to the back injuries to ,thecaptain and first officer, the captain and the forward cabin stewardess received bruises and lacerations of the head. The aft cabin stewardess was uninjured.

Passenger injuries consisted of bruises, lacerations, and strains. A number of female passengers received frostbitten feet walking from the aircraft to the runway, after losing their shoes in the snow. Additional injury information is contained in Section 1.14, Survival Aspects.

1.3 Damage to Aircraft

The aircraft was damaged beyond economical repair by ground Impact and the subsequent slide through trees. The wings were torn and crumpled extensively. The wing fuel cells were ruptured. The left wingtip and tip extension were separated from the wing. The fuselage was predominantly intact with the exception of major distortion, tearing, and wrinkling of the skin and associated structure. The empennage, both engines, and the major portion of both wings remained attached to the fuselage. The empennage was intact but there was some tearing and crumpling of the empennage skin. The tail cone and the ventral stair opening were damaged severely. Additional damage information is contained in Section 1.12, Wreckage.

1.4 Other Damage

A number of trees were destroyed in the wreckage path.

1.5 Crew Information

The crew of Flight 982 was currently certificated and qualified in accordance with the Federal Aviation Regulations,

Captain Sweeney, aged 48, had accumulated a total of 19,145 flight-hours, of which 63 hours were in the DC-9.

First Officer Schmelz, aged 33, had accumulated a total of 6,048 flight-hours, of which 20 hours were in the DC-9.

The flightcrew reported for duty, originating their scheduled sequence of flights at 0705, December 26, 1968. in St. Louis, Mo., and terminated the first sequence of flights at O'Hare International Airport at 1211. Following a rest period of 8 hours and 24 minutes, they reported for duty at 2035 and terminated at Sioux Falls at 0026, December 27, 1968. Following a rest period of approximately 5 hours at a motel, they reported for duty at Sioux Falls at 0525.

A review of the training records of the flightcrew confirmed that use of the anti-ice systems and takeoff power requirements were included in the DC-9 ground school training. In accordance with the Ozark Air Lines DC-9 Training Manual, the airfoil anti-icing was required when the temperature was +6° C. or lower and visible moisture was present in the air, or whenever icing was anticipated or expected. In addition, the responsible FAA inspector stated that these items were also included in his oral examinations of Ozark Air Lines' flightcrews applying for their DC-9 type rating, The review of the Ozark Air Lines DC-9 Training and Operations Manuals disclosed no exceptions that would imply that takeoffs with ice adhering to the airfoils was acceptable.

Appendix B contains detailed crew information.

1.6 Aircraft Information

The aircraft was certificated properly and had been maintained in accordance with existing requirements, with the exception of an unreported malfunction of the cockpit voice recorder.

The baggage and cargo were removed from the wreckage and weighed. The actual weight of the baggage was 2,006 pounds, as compared to 2,201 pounds listed on the load manifest. The actual weight of the cargo, which consisted of mail, was 329 pounds as compared with 317 pounds listed on the load manifest. The weight and balance listed on the load manifest were computed from approved tables contained in the operations manual, which are based on an average winter weight of 170 pounds per passenger, plus an average of 23.5 pounds per piece of luggage. The actual cargo weight was used.

Computation of the weight and balance at departure from Sioux City, based on the average winter passenger weight of 170 pounds and the actual weight of the baggage and cargo removed from the wreckage, resulted in a gross weight of 88,149 pounds as compared with 88,332 listed on the load manifest.

The c.g. 3/ was computed to be 25 percent MAC 4/ well within limits and compatible with the selected horizontal stabilizer trim, as determined during wreckage examination.

The maximum allowable takeoff gross weight for this aircraft was 90,700 pounds utilizing -1 power 5/. However, the maximum allowable gross weight for this takeoff was further limited to 89,000 pounds by computed fuel burnoff and the maximum allowable landing gross weight at O'Hare International Airport, the destination.

The load manifest listed a departure gross weight of 88,132 pounds, which required the use of -1 power (14,000 pounds of thrust per engine). In accordance with Ozark procedures, this power requirement was noted on the completed weight and balance form given to the captain prior to departure from the ramp.

During the examination of the cockpit, the EPR 6/ gauges were found to be set at 1.85, which was the setting for -5 power. The flightcrew confirmed that the power was selected to 1.85 EPR for this takeoff.

3/ c.g.--center of gravity

4/ MAC--mean aerodynamic chord

5/ The engines installed in this aircraft were the JT8D-7 model which were rated at 14,000 pounds takeoff static thrust at sea level, to 84° F. ambient temperature. The -1 model of this engine is rated at 14,000 pounds of takeoff static thrust at sea level, to 29° P. ambient temperature. The -5 model of this engine is rated at 12,250 pounds of thrust.

Engine life considerations permit the use of -5 power (12.250 lbs. of thrust) for takeoff with the -7 engine installation. providing that gross weight, density altitude, and runway allow the aircraft to meet takeoff and structural climb requirements with that power setting. Tables establishing the requirements for the use of -5 or -1 power were contained in the Ozark DC-9 Operating Performance Manual. Regardless of density altitude and runway considerations, second segment climb requirements, with one engine operating, limits the maximum takeoff gross weight using -5 power to 85,100 pounds.

6/ EPR--engine pressure ratio

Performance differences at -1 and -5 power are listed as follows:

	-5	-1
Time required to accelerate to lift-off	33.9 Sec.	28.6 Sec.
Distance required to accelerate to lift-off	4,165 feet	3,500 feet
Computed KIAS 7/ at lift-off plus 35 feet	153.5	156.4

The aircraft was fueled with a total of 24,600 pounds of Jet A-1 fuel at Sioux City.

1.7 Meteorological Information

A weather briefing of this crew was not requested from or provided by the Weather Bureau at either Sioux Falls or Sioux City. However, pertinent weather information was available at both weather stations and was made available to the flightcrew by company personnel.

The 0600 surface weather chart prepared by the National Meteorological Center showed a low-pressure system center over northern Missouri, a warm front extending eastward from the low-pressure center, and a cold front extending southwestward from the low-pressure center to the Texas Panhandle, then northwestward to New Mexico and becoming quasi-stationary and continuing northwestward to northern Colorado.

The Weather Bureau forecasts pertinent to Iowa were issued by the forecast center at Kansas City. The aviation terminal forecast for Sioux City issued at 0445, valid 0500 to 1700, was in part as follows:

> 0500-1100, ceiling 500 feet obscuration, visibility 2 miles, light freezing drizzle, fog, wind 030°, 19 knots, occasional ceiling 300 feet obscuration, visibility 1 mile freezing drizzle, fog.

The aviation area forecast issued at 0645, valid 0700 to 1900, pertinent to Nebraska (except Panhandle), Iowa, Kansas, and Missouri, contained the following remarks pertaining to icing:

> Icing: Moderate to locally heavy mixed icing in clouds and precipitation below 10,000 feet and in thunderstorm tops. Freezing level surface Iowa, Nebraska, western Kansas and most of central Kansas sloping up to 9,000 feet southeast Missouri.

7/ KIAS--knots indicated airspeed

The surface weather observations at Sioux City near the arrival and departure times of Flight 982 were as follows:

0657, measured 800 feet overcast, visibility 3 miles, light freezing drizzle, fog, temperature 22° F., dew point 20° F., wind 360° 10 knots, altimeter setting 29.68 inches.

0714 local, measured 700 feet overcast, visibility 3 miles, light freezing drizzle, fog, temperature 22° F., dew point 20° F., wind 020°, 13 knots, altimeter setting 29.68 inches.

Weather observations for Sioux City showed that glaze continued from midnight to 1105, and either very light or light freezing drizzle also continued from midnight to 1105.

Glaze is defined by the Weather Bureau as follows: "A coating of ice, generally clear and smooth but usually containing some air pockets, forms on exposed objects by the freezing of a film of super cooled water deposited by rain, drizzle, fog, or possibly condensed from super-cooled water vapor. Glaze is denser, harder and more transparent than either rime or hoar-frost."

An Inflight Weather Advisory pertinent to Iowa issued at 0545, valid 0545 to 1000, in addition to low ceilings. visibilities and freezing rain, advised of moderate to locally heavy mixed icing in clouds.

According to pilot reports, the top of the overcast in the Sioux Falls area at 0840, was 4,700 feet m.s.l. The top of the overcast in the Sioux City area at 0857 was 6,500 feet m.s.l.

Official sunrise at Sioux City on this date was 0754.

18 Aids to Navigation

Not applicable.

19 Communications

There were no communication difficulties associated with this accident.

1.10 Aerodrome and Ground Facilities

The Ozark station at Sioux City was manned by station agents only, There were no mechanics assigned. Aircraft deicing equipment was available at this station and station personnel were familiar with ground deicing of aircraft.

Runway 35 at the Sioux City Airport is 6,601 feet long and 150 feet wide. The published elevation is 1,097 feet m.s.l.

On the morning of the accident. the surface of Runway 35 was dry with large patches of hard packed snow and ice. The pilot of a DC-9, which landed on Runway 31 approximately 4 hours after the accident, reported the braking action as fair, although he did note poor nose wheel traction while making a 180° turn on the runway.

The terrain beyond the end of Runway 35 was relatively flat and covered with approximately 22 inches of snow. The terrain along the extended runway centerline was clear of obstructions for a distance of approximately one-half mile, except for a strand wire fence perpendicular to the runway heading. The terrain, beginning approximately 250 feet left of the extended runway centerline, was covered with a dense growth of small trees with occasional larger trees with trunk diameters of 10 to 12 inches.

1.11 Flight Recorders

(a) Cockpit Voice Recorder

N974Z was equipped with a United Control Cockpit Voice Recorder (CVR), Model V-557, SIN 1885. There was no damage to the CVR at the time it was removed from the wreckage.

Examination of the CVR disclosed that the tape was jammed. A playback of the tape disclosed that voices were last recorded on the tape during a flight to Dubuque, Iowa, December 25, 1968, 2 days prior to the accident.

Further examination disclosed that proper operation of the self-test feature of the CVR would have revealed this malfunction. Testing of the CVR was required by the Ozark Air Lines prestart checklist upon the origination of the first flight each day and upon a flightcrew change. Subsequent to the malfunction of the CVR, there were six occasions requiring that the CVR be tested, which included two occasions by the flightcrew involved in this accident. This flightcrew was responsible for testing the CVR upon accepting this aircraft on the day before the accident and again upon origination of the subject flight from Sioux Falls on the morning of the accident.

If a malfunction of the CVR is detected, the flight is permitted to continue until the aircraft passes through a station capable of correcting the discrepancy. Subsequent to the first required test of the CVR after the malfunction, this aircraft passed through the Chicago O'Hare International Airport, Ozark Air Lines Station seven times. This station has the capability of replacing the CVR.

Testing of the CVR is accomplished by depressing the self-test button on the CVR for approximately one-half second. The needle of a test meter, also located on the CVR, should deflect immediately and return to zero, then following a momentary delay, again deflects and returns to zero, indicating that the tape is moving and the recording channels are functioning properly. In this case, depressing and releasing the test button would cause no deflection of the needle, since the tape was not traveling. The requirement for two deflections of the needle of the test meter was explained in the Ozark Air Lines DC-9 Operating Performance Manual.

The captain stated that he had complied with the originating checklist prior to departing Sioux Falls but he could not positively state that the CVR was tested. He did indicate that he was aware that two deflections of the needle of the test meter were required as an indication of a properly functioning CVR.

(b) Flight Data Recorder

N974Z was equipped with a Fsirchild Model 5424-502 flight data recorder, S/N 5370, which was recovered from the wreckage intact with no evidence of damage.

The recording medium was readable and all parameters were functioning throughout the flight, beginning with the departure from Sioux Falls.

The appearances of the recorded traces were normal and consistent with the takeoff, with the exception that the altitude trace during both the landing roll and takeoff roll at Sioux City, recorded a reading of 128 feet above the published airport elevation. Also, the airspeed trace, during the takeoff roll at Sioux City, contained some unexplained excursions, both up and down, beginning 4 seconds prior to the dip in the altitude trace, typical of rotation and lift-off. The flight data recorder was submittedto the manufacturer for examination and testing. Examination of the recorder did not disclose any abnormalities and the unit tested within allowable tolerances, which were ± 100 feet at the elevation of the airport.

Examination of the pitot static system disclosed *no* evidence of ice that would have influenced the airspeed indicators or altimeters.

Since the error in the altitude trace was consistent at Sioux City this error was applied to all altitude considerations. For performance computation purposes, the excursions in the airspeed trace, beginning approximately 4 seconds prior to the dip in the altitude trace, were averaged into the general profile of the airspeed trace. Also, as the altitude trace became erratic immediately following the first dip in the trace, a meaningful reading of recorded altitude increase could not be made.

The airspeed readings for each second, beginning with the first detectable increase in the trace, were converted to feet per second groundspeed. The times and distances were then compared with the computed performance takeoff profile for this aircraft with no ice adhering to the aircraft structure, but with the remaining conditions which existed at the time of the accident. The comparisons were as follows:

a.	Flight recorder time from beginning of increase in the airspeed trace to V_1 (136 KIAS)	28	sec.
	Computed performance time required to V_1 (136 KIAS)	30.3	sec.
b.	Computed flight recorder distance to V_1	3,110	ft.
	Computed performance distance required to V_1	3,410	ft.
c.	KIAS at dip in flight recorder altitude trace	133	KIAS
	Recommended rotation speed, V_R	139.3	KIAS
d.	Computed performance V_{LO}	148	KIAS
	Computed performance distance to V_{LO}	4,165	ft.
	Flight recorder computed distance to 148 KIAS	4,217	ft.
e.	Plight recorder time from beginning of increase in airspeed trace to 148 KIAS	31	sec.
	Computed performance time required to V_{LO} (148 KIAS)	33.9	sec.

The flight data recorder time and distance computations were compared with the measured distance the aircraft actually traveled from the beginning of the takeoff roll to the point the aircraft came to rest. This distance as computed from the flight data recorder was 7,422 feet. The actual distance as measured was 7.183 feet, or a difference of 239 feet.

A chart comparing the manufacturer's computed expected acceleration for this takeoff and the acceleration as determined from the flight data recorder is shown in attachment 1.

1.12 Wreckage

The first item of aircraft wreckage found along the takeoff path consisted of a small piece from the left wingtip which was found approximately 580 feet from the departure end of the runway. From this point to the end of the runway, small pieces of glass, pieces of the left wing landing light frame, rivets, and a 6-inch rection of the left outboard wing trailing edge door were found.

The first identifiable ground scar commenced 110 feet beyond the end of the runway. A blade of a UHF antenna and an APU fairing were found at this point. The wreckage path then continued on a heading of 334° magnetic to the position where the wreckage came to rest, 1,181 feet beyond the end of the runway and 325 feet west, or left, of the extended runway centerline. The aircraft came to rest on a heading of 095°. Numerous trees were uprooted and knocked down in the wreckage path as the aircraft entered a woods located approximately 250 feet west of the extended runway centerline.

The left wingtip and associated small pieces were found, commencing approximately 280 feet beyond the end of the runway. Pieces from both wings and pieces of the nose and bottom of the fuselage were found commencing at the point where the wreckage path entered the woods and continued to the point where the wreckage came to rest.

Examination of the cockpit disclosed no items adverse to the takeoff of the aircraft, with the exception that the EPR setting was 1.85 (-5 power, 12,500 pounds of thrust).

The flap selector was in the 20° position and the landing gear selector was in the "up" position.

The cockpit was intact with exception that the right side, adjacent to the first officer's seat, was torn and displaced inboard as a result of tree impact which also displaced the first officer's seat inboard.

The flaps were determined to have been extended to the 20° position, in agreement with the cockpit selector position, and the landing gear was determined to be retracted, also in agreement with the cockpit selector position. The horizontal stabilizer trim was found to be in agreement with the cockpit setting and compatible with the c.g.

The separated left wingtip contained abrasive scraping, resulting from contact with the runway.

Both engines were intact with visible damage limited to cowling distortion, and tree, brush, and snow ingestion, Examination confirmed that the difficulty in securing the left engine was a result of binding of the engine control linkage caused by fuselage damage.

Examination and testing of all the aircraft components pertinent to this accident disclosed no evidence of preimpact failure or malfunction.

The accumulation of ice on the right wing could not be determined since the leading edge was completely distorted and torn throughout its entire length.

The inboard section of the left wing leading edge was intact with no distortion. A sheet of semiclear, rough, solid ice was firmly adhered to the left wing immediately aft of the leading edge, except for patchy irregular areas free of ice which were associated with ice being shed as a result of impact forces. The remaining ice extended from approximately 8 inches behind the leading edge on the top surfaces to approximately 16 inches aft of the leading edge on the bottom surface. The leading edge was free of ice except at the stall strip. The irregular pattern of the ice between the ice covered area aft of the leading edge, and the clear area at the leading edge, was indicative of impact shock shedding of the ice at the leading edge. The remaining attached ice was an estimated one-eighth of an inch thick at the forward edges, tapering to approximately one-sixteenth of an inch at the aft edges. The ice adhering to the stall strip was estimated to be one-fourth of an inch thick.

The leading edges of the entire empennage were completely covered by solid ice, similar in texture to that found on the left wing. This ice was estimated to be three-eighths of an inch thick at the leading edge and extended back equally on both sides of the surface, a distance estimated as 6 to 8 inches.

The contour pattern of the ice was compatible with ice that is formed during flight. It was not compatible with the ice that formed on the other aircraft surfaces during the ramp time at Sioux City.

1.13 Fire

There was no fire.

Wreckage examination confirmed that the fuel tanks were ruptured prior to the time the aircraft came to rest, An estimated 2,200 gallons of fuel emptied from the ruptured fuel tanks and a heavy fuel odor permeated the area around the fuselage.

Absorption of the fuel by the 22 inches of snow on the ground and the reduced vaporization as a result of the 22° temperature were considered major reasons for the absence of fire. The left engine, which continued to run, could have provided the ignition source.

1.14 Survival Aspects

The absence of fire and minimal deceleration loads in the occupied areas resulted in this being a survivable accident.

(a) Evacuation

.The passengers in the first class section evacuated the aircraft through the left forward cabin door. This door was against a tree, resulting in some delay at this exit because of the difficulty in opening the door.

The passengers in the coach section evacuated through both the right and left window exits. The aft stewardess considered evacuations through the rear stairway exit. After checking the damage to this exit through the observation window in the aft door, she decided against using it for evacuation. Subsequent examination of the rear stairway exit disclosed that this evacuation route appeared to be blocked, especially when viewed through the small, observation window. The aft cabin door could be opened by normal means and it was possible to exit through the aft stairwell; however care would have been required to avoid injury from the jagged metal. Damage to the aft underside of the fuselage provided an opening to the outside.

Neither crewmember was wearing a shoulder harness. The captain rtated that during the final swerve of the aircraft, both flight crewmembers were thrown violently to the right and, at this time, he felt something give in his back, accompanied by a sharp pain. It was determined that at this time hie head struck the radio panel located on the center pedestal. Functional testing of the shoulder harness indicated that had they been worn, they would have restricted the deflection of his body sufficiently so that most probably the injury to his back would not have occurred.

Although there was no distortion or damage in the area of the forward cabin stewardess seat, which is attached to the bulkhead between the cabin and the flight deck, the seat separated at the left attach point. Head injuries suffered by the stewardess were most probably caused by striking the protruding handhold adjacent to her seat.

No problem was described by any of the occupants evacuating through the window exits over the wing, other than that the wings were icy and slippery. It was of interest to note that the passenger seated in the aisle seat by the left window exit stated that he was fully aware of how to open the window exit since, prior to departure, he had read the emergency instructions contained in the pamphlet located in the seat pocket in front of him.

Some passengers stated the illumination level in the cabin was very low during the evacuation.

The aircraft was equipped with an emergency lighting system, independent of the aircraft electrical system. This system nay be operated manually by switch selection or automatically when the aircraft system electrical power is interrupted. The illumination provided by these lights is sufficient to identify known objects and some colors and to permit movement to the exits; however, it is not sufficient to read a newspaper or magazine. Examination of this system disclosed the switch positioned to the armed position, the batteries discharged and no evidence of a malfunction that would have precluded their automatic operation. Several passengers confirmed that they observed illuminated lights in the cabin during the evacuation,

No other specific evacuation problems were identified other than that some passengers, concerned with collecting their personal belongings, increased the evacuation time.

(b) Cockpit/Cabin Integrity

The first officer's seat and the forward stewardess seats failed or were displaced as described above.

The passenger seats remained Intact with the exception of seats C, D, and E, row 7, located on the right side of the coach section. This row of seats was separated and displaced to the left, partially blocking the center aisle. The passengers occupying these seats were hospitalized. Damage to these seats resulted from tree impact on the right side of the fuselage, adjacent to this row of seats.

The fuselage immediately forward of the forward left seat in the first-class section was damaged, torn, and displaced inboard by tree impact. The passenger occupying this seat received lacerations.

(c) Emergency Equipment

At the time of the accident, there was no municipally operated emergency equipment based on the Sioux City Airport. There were three primary structural fire vehicles, not foam equipped, owned and operated by the U.S. Air Force based on the airport.

In the past, the airport had relied on the Iowa Air National Guard, based on the field, for emergency equipment and personnel in the event of an aircraft emergency. However, the Air National Guard had been called to active duty and their facilities were placed in a caretaker status.

Emergency equipment was available in Sioux City, 6 miles from the airport.

There were no existing written agreements or plans covering emergency vehicle and personnel response to aircraft emergencies at the airport.

1.15 Tests and Research

The flightcrew did not report any difficulties during the approach and landing at Sioux City. They also described the lift-off as normal, followed by a positive rate of climb prior to the loss of control, In view of this apparent normal performance through lift-off with ice adhering to the airfoils, the investigation included a review of several studies relative to ground effect and airfoil icing. These studies disclosed the following:

(a) Ground Effect

In general, ground effect is an area of increased lift created by the effect of the surface in turning the induced flow from the wings of an aircraft flying near the surface, thus reducing induced drag and increasing lift 8/. At a height above the ground equal to the wing span of an aircraft, the reduction in induced drag is only *14* percent, whereas, at a height equal to one-tenth the span, the reduction in induced drag ia *47.6* percent 9/. The wing span of the aircraft involved in the accident was *87.4* feet.

An aircraft leaving ground effect will require an increase in angle of attack to maintain the same lift coefficient. Thus an aircraft with an accumulation of ice on the airfoil during takeoff may become airborne. However, it could be so close to stall speed that as it reaches the area of reduced lift and increased induced drag, near the upper limits of ground effect, flight cannot be maintained.

8/ Frank Davis Adams, Aeronautical Dictionary; National Aeronautics and Space Administration, 1959.

9/ H. H. Hurt, Jr., Aerodynamics for Naval Aviators; NAVWERPS 00-80T-80, U.S. Navy, 1960.

(b) Icing

NACA Technical Note 4155 10/, NACA Research Memorandum, RM 53330 11/, and NASA Technical Note D-2166 12/ are reports of studies of the effects of icing on unswept and swept airfoil. Tests conducted during these studies demonstrated that airfoil icing does result in aerodynamic penalties that, in general, resulted in higher stall speeds and lower stall angles of attack. One of the tests also showed that rotation of an iced airfoil to angles of attack, other than that at which icing occurred, generally created aerodynamic effects different from those that would result when the airfoil was positioned at the angle of attack at which the ice was accumulated. In one test, such rotation caused sufficiently large changes in the pitching-moment coefficient that, in flight, rapid corrections in trim might be required in order to avoid a hazardous situation. The effect of rotation of an iced airfoil is significant to this accident in that, during the descent through the icing conditions approaching Sioux City, the aircraft was flown predominantly at angles of attack between ± 2°, whereas, angles of attack several times greater occur with the DC-9 during and immediately following lift-off.

The hazards of takeoffs with ice were recognized by the Federal Aviation Regulations and the Ozark Airlines Operations Manual which prohibit takeoffs with ice as follows:

Federal Aviation Regulation 121.629 states:

> "No person may take off an aircraft when frost, snow, or ice is adhering to the wings, control surfaces, or propellers of the aircraft."

Ozark Air Lines Operations Manual states:

> "No flight shall take off with ice, snow or frost adhering to propellers. wings, or control surfaces. It shall be the responsibility of the Captain to have all such ice, snow, or frost removed from the propellers, wings and control surfaces and any part of the aircraft which the captain considers detrimental to flight. . ."

10/ Vernon H. Gray and Uwe H. von Glahn. Aerodynamic Effects Caused by Icing of an Unswept Airfoil, National Advisory Committee for Aeronautics, 1958.

11/ Uwe H. von Glahn and Vernon H. Gray. Effect of Ice Formations on Section Drag of Swept NACA 63-009 Airfoil with Partial Span Leading-Edge Slat for Various Modes of Thermal Ice Protection; National Advisory Committee for Aeronautics, 1954.

12/ Vernon H. Gray. predicition of Aerodynamic Penalties Caused by Ice Formations on Various Airfoils; National Aeronautics and Space Administration, 1964.

1.16 Other Information

(a) Stall Warning

The aircraft was equipped with a stall warning system which through a lift transducer mounted in each wing, measures the stagnation point, or angle of attack. The system is programmed to activate a stick shaker stall warning at approximately a constant angle of attack which provides adequate warning before the stall angle of attack is reached.

The crew did not recall receiving a stall warning.

(b) Anti-Icing System

The captain stated that he used engine anti-ice during the descent through the cloud layer to Sioux City but did not use airfoil anti-ice. Neither crewmember provided an explanation of why the aircraft anti-ice system was not utilized for the descent through this cloud layer, although Icing conditions were forecast, other than they did not think it was needed.

Ozark Air Lines DC-9 Operating Performance Manual states:

> "To prevent build-up of ice accumulations on the airfoil which could later break free from surfaces when heat is applied, the airfoil anti-icing shall be turned on as well as the engine anti-icing, when the temperature is +6° C. or lower, and moisture is present in the air, or whenever icing is anticipated or expected. It is permissable to turn on airfoil anti-icing just prior to takeoff when icing is expected to occur as the aircraft enters the overcast.
>
> "The only exception to this rule of not using airfoil anti-icing with engine anti-icing is while operating in clear air at altitude, and engine anti-icing is necessary to prevent icing of the P. T. probes."

The design of the airfoil anti-ice system on this aircraft precluded activation of this system until nose wheel lift-off, even though the cockpit switch was on. Power loss considerations further resulted in a company operation policy further restricting use of the wing anti-ice system until a height of 400 feet had been obtained.

(c) Speed Control--Lift Instrumentation System

The aircraft was equipped with a lift instrumentation system which, through measurement of the stagnation point by the lift transducers mounted in each wing, provides a cockpit presentation on the flight director command bar. With selection of the takeoff mode, this system programs the proper attitude to give a deck angle of 15° after lift-off.

On December 18, 1968, the aircraft involved in this accident was used on a training flight during which a malfunction of the speed command system occurred. It was reported that during takeoff, after initial compliance with the speed command information, the command bar then indicated continuous agreement with pitch attitude regardless of changes of pitch. This same malfunction recurred later in the flight during a simulated, single-engine go-around. The corrective action taken was replacement of a defective computer.

The Air Line Pilots Association coordinator assigned at the accident site advised that similar malfunctions occurred to this aircraft on December 21, 1968, and December 22, 1968. No entry reflecting a malfunction of this system was recorded in the aircraft log for these dates.

Regardless of rotation information provided by this system, published operating instructions restrict all takeoff rotations to a maximum of 15° on the flight director.

Examination and testing of this system subsequent to the accident disclosed no evidence of failure or malfunction.

(d) Stall Recovery Incidents

The investigation disclosed two incidents of unexpected violent rolls and delayed recoveries during approach to stall maneuvers on training flights in this model aircraft.

One incident was the subject of a Federal Aviation Administration Incident Report Involving another airline, which occurred near Augusta, Georgia, on January 19, 1967. The remarks section of this report quoted in part as follows:

> "Aircraft departed ATL 1/19/67, 0611EST, on training flight with two students and an Instructor. ATL 0600WX was 5000 broken 6000 overcast 12 miles in light rain, temperature 41. The aircraft climbed IFR via radar vectors through icing conditions with anti-icing systems operating. At 0620E aircraft reported on top and cancelled IFR. At 0745 E, at 16,500' a

"series of stalls were begun (location 26 DME miles from AGS 340 radial). In landing configuration and normal entry, approximately 68,000 lbs gross, C.G. 29.0 o/o, aircraft trimmed 3.5 degrees nose up and manual elevator force for stall entry, the stick shaker indicated approach to stall. Closely followed one definite stall buffet and lateral control loss. Left wing dropped. Nose was lowered to horizon bar as flaps were retracted to 20 degrees. Pitch attitude decreased to 10 degrees nose down, bank increased to 60 degrees to left. Airspeed was now about 160K. Roll recovery attempted along with pitch recovery. Aircraft did not respond; however, another sharp buffet was experienced as the roll continued left. As airspeed increased to 200K landing gear was retracted. A roll recovery was successful with steep nose down attitude* * *."

Discussion with the FAA inspector assigned to this incident disclosed that airfoil icing was suspected to be a factor in this incident, however, it was not confirmed.

The other incident occurred to an Ozark DC-9-15 on March 3, 1969. This incident was reported to the National Transportation Safety Board by the FAA inspector who was aboard the aircraft observing a pilot-in-command flight check and who also had been the assigned FAA coordinator during the investigation of the accident, which is the subject of this report.

According to hls report, this aircraft had climbed through an overcast and leveled off at 15,500 feet m.s.l. for approach to stall maneuvers. An estimated one-eighth of an inch of a mixture of rime and clear ice was observed on the windshield wiper post.

The first approach to stall was in the clean configuration at a gross weight of 75,000 pounds, V_2 computed at 130 knots. No elevator trim was applied after 175 knots. The stick shaker stall warning was received at 137 knots and a normal recovery was made using 20° of flaps.

The next maneuver was an approach to stall in the 20° flap configuration while executing a 20° banked turn to the left. V_2 was computed at 130 knots, no elevator trim was applied after 151 knots. The stick shaker stall warning was received at 114 knots, at which time the pilot applied takeoff power and rudder and aileron to roll out of the turn. The moment rudder was applied the right

wing stalled and the aircraft rolled violently to the right. At this time the aircraft was in a 5° noseup attitude. The controls were reversed and the aircraft rolled violently to the left. The aircraft continued to buffet violently at an airspeed of 175 knots. Recovery was made with approximately a 15° nosedown attitude and a loss of altitude of approximately 1,500 feet.

After recovery, the maneuver was repeated again with the exception that during recovery aileron only was used to roll the aircraft level. Abnormal buffeting was experienced; however, no unusual control difficulties were noted.

The airfoils were then deiced and the maneuver repeated. This time the recovery was normal with only light buffeting.

2. ANALYSIS AND CONCLUSIONS

2.1 Analysis

The examination of the aircraft structures, components, systems and powerplants revealed no indication of preimpact failure or malfunction. The causal area therefore primarily involves the actions and judgment of the crew in attempting a takeoff with a known accumulation of ice.

Crew fatigue, as a potential factor in the accident, was considered in the course of the investigation, in view of the pilot's arrival at Sioux Falls at 0026 and the time the crew subsequently reported for duty at 0530 the same morning. The rest and duty time of this crew during the preceding 24-hour period met the minimum crew rest requirements of the Federal Aviation Regulations. Because of their schedule, however, fatigue of a degree may have existed. The degree of fatigue and the influence it may have had in the decisions made by the captain in this accident are difficult to evaluate. While fatigue can influence a flight crewmember to deviate from established procedures, consideration of all the factors of this accident, as will be discussed later in this section, makes it doubtful that it existed to the extent that it caused the captain not to realize the significance of the ice reported to be adhering to the airfoil of the aircraft. These considerations also make it doubtful that fatigue played a role in his decision not to deice the aircraft, or in his failure to recognize the proper power required for this takeoff.

Following departure from Sioux Falls, the flight climbed through an overcast approximately 2,000 feet thick, and then was on top of the overcast at its assigned altitude of 11,000 feet m.s.l. until entering the overcast at 6,500 feet m.s.l. during descent to Sioux city.

The ceiling on arrival was 700 feet above the ground. According to the flight recorder, approximately 11 minutes were required for the descent through the overcast. Although moderate to locally heavy mixed icing was forecast in clouds and precipitation, the captain elected not to use the airfoil anti-ice during penetration of this overcast; however, he did use engine anti-ice. The captain offered no explanation as to why he elected not to use airfoil anti-ice other than he did not think it was needed.

The Board finds this reasoning difficult to accept in that company policy, sound operating procedures, and good pilot judgment, in consideration of the existing weather conditions, dictated the selection of both engine and airfoil anti-ice.

As an iced airfoil no longer retains the aerodynamic characteristics of the clean airfoil, the precise characteristics of the iced airfoil are somewhat unpredictable. NASA studies have confirmed that aerodynamic penalties do result in higher stall speeds and lower stall angles of attack. Therefore, the approach and landing at Sioux City, flown at the performance figures for a clean airfoil, were exposed to possible control difficulties.

The approach and landing at Sioux City were most probably completed without incident because they were flown at near the same angle of attack as the angle of attack at which the ice was accumulated and the benefit of the increased lift as the aircraft descended into ground effect during the landing flare; whereas, during lift-off the aircraft was rotated to an angle of attack most probably 7° to 9° greater than the angle of attack at which the ice was accumulated, coupled with the reduced lift as the aircraft was departing ground effect.

Upon arrival at the ramp, and being advised that ice was adhering to the aircraft, the captain declined the station agents' offer to deice it. Also, neither the captain nor the first officer left their seats to personally examine the reported ice, The captain explained that as the ice did not cause him any problem on approach and landing, he did not expect it to give him a problem on takeoff. He further steted that during his previous flying career in Douglas DC-3, Martin *404,* and Fairchild F-27 aircraft, he had at times made takeoffs with ice adhering to the airfoils, following an approach and landing with the ice, in which no difficulty was experienced.

The Board further concludes that under the circumstances, the aircraft should have been deiced before takeoff. Studies, actual experience, training, and the regulations have long emphasized the aerodynamic penalties of takeoff with ice adhering to the airfoils.

NASA studies have determined that the magnitude of the aerodynamic penalties resulting from an iced airfoil were primarily a function of the shape and size of the ice formation near the leading edge of the airfoil. These studies also showed that rotation of an iced airfoil to angles of attack, other than that at which icing occurred, caused sufficiently large changes in the pitching-moment coefficient that, in flight, rapid corrections in trim might be required in order to avoid a hazardous situation. This would seem to be confirmed by the two training incidents in which unexpected violent rolls and delayed recovery were experienced during approach to stalls with known or suspected airfoil ice.

Although the takeoff gross weight of the aircraft required the use of -1 power (14,000 pounds of thrust per engine). and this power requirement was clearly identified on the completed weight and balance form given to the crew by the station agent, the crew selected -5 power (12,250 pounds of thrust per engine) for this takeoff. No explanation was offered by the crew for this power selection other than that they failed to recognize the gross weight power requirement. The Board can only conclude that the crew failed to check the weight and balance form, they read it erroneously, or they were notthoroughly knowledgeable of the power requirements of this aircraft. Although the crew had satisfactorily completed the prescribed training in this model aircraft, their actions on this flight did not demonstrate a thorough knowledge of the thrust requirements or of the use of the anti-ice systems. While it cannot be substantiated that the use of -1 power would have prevented this accident, the increased acceleration would have increased the probability of a successful takeoff.

Although tower personnel, a number of passengers, and ground witnesses thought that the takeoff acceleration of this aircraft was slow, a comparison of the acceleration, as determined from the flight data recorder with the computed expected acceleration, disclosed that the acceleration was very near the computed expected acceleration for the power setting selected. The setting actually used by the crew for this takeoff, while not in accordance with performance requirements, was adequate to permit a successful takeoff on Runway 35, with clean airfoils. The increased power required for the existing gross weight is stipulated to meet the single-engine climb requirements in the event of an engine failure following takeoff.

The flightcrew confirmed that lift-off did occur and that a positive rate of climb was noted prior to the loss of control. The review of the flight data recorder readout indicated that lift-off occurred at near the computed performance lift-off speed. This might seem to question the influence of the aerodynamic effect of the ice adhering to the airfoils of the aircraft during this takeoff.

However, studies have confirmed that the increased lift obtained from ground effect may permit an aircraft with iced airfoils to become airborne and subsequently be unable to maintain flight when entering the area of reduced lift leaving ground effect.

The accurate weight, size, and shape of the ice adhering to this aircraft at the time loss of control was experienced could not be determined; therefore, the extent of aerodynamic penalties resulting from this ice accumulation could not be determined. Also, determination of the aerodynamic effect of ice on a specific airfoil is not a requirement in the certification of the aircraft. Even if this were a requirement, it would be virtually impossible to determine the aerodynamic penalties of the various shapes and textures of ice that may be accumulated in flight.

Studies conducted by the National Advisory Committee for Aeronautics and later by the National Aeronautics and Space Administration, Federal Aviation Administration publications, and the textbooks previously cited, have confirmed that airfoil icing does result in aerodynamic penalties and that, in general, these penalties result in higher stall speeds and lower stall angles of attack.

In view of the foregoing, the Board concludes that airfoil icing existed to such an extent that substantial aerodynamic penalties were imposed. These penalties, while not precluding the aircraft from becoming airborne and briefly establishing a positive rate of climb in ground effect, resulted in a stall as soon as it lost the advantage of ground effect. Accordingly, except for ground effect, the aircraft probably would not have become airborne under the existing circumstances.

The experience level of the flightcrew in this model aircraft was minimal. However, the Board believes that the relatively low level of experience should not have been a factor in the accident, since icing effect on the airfoils of an aircraft is basic knowledge required of all certificated pilots. While ice is more critical on a thin swept-wing aircraft, the same basic precautions are applicable to all aircraft regardless of airfoil design.

The Board concluded that the validity of information provided by the speed command system and the stall warning system with an iced airfoil is questionable. A stall can occur with an iced airfoil at a lower angle of attack than that programmed for the stall warning system and, under extreme icing conditions, the validity of the information provided by the speed command system becomes questionable. However, proper use of the airfoil anti-ice system and proper deicing of aircraft prior to departure would eliminate this operational consideration.

The popping and torching of the engine near the time of the stall resulted from engine compressor stalls caused by the crew's manipulation of the throttles during their attempted recovery and subsequent abandonment of the takeoff, and disturbed engine inlet airflow resulting from the stabled attitude of the aircraft. This phenomenon has been observed in other jet aircraft accidents.

Passenger and stewardess interviews indicated that some passenger efforts to retrieve personal items may have delayed evacuation, dictating continued emphasis on the command presence and leadership of the flightcrew during evacuation. This important leadership was demonstrated in this evacuation by those crewmembers who were physically able to direct the evacuation. However, it must be noted that injuries to the flightcrew and the forward stewardess limited the early and effective leadership necessary in this situation. Wearing of shoulder harnesses by the captain and first officer, increased integrity of the forward stewardess seat, and recessing of **all** hardware adjacent to the forward stewardess seat would have most probably prevented injuries to these three crewmembers, thus assuring the availability of their leadership during the evacuation.

The Board cannot overlook the undetected malfunction of the cockpit voice recorder (CVR), which occurred **2** days prior to the accident. Neglect of the operating condition of the CVR could, at sometime, deprive the Board of valuable information during the investigation of an aircraft accident. While this omission in itself was not of major significance in this accident, the fact that the malfunction remained undetected by this flightcrew on two occasions and by four other flightcrews on four other occasions, reflects **a** general tendency to deviate from established procedures.

The Board believes that the evidence of record contains **a** number of factors which reflect adversely **on** the quality of managerial supervision. While these factors were adequately covered in the company operating manuals and by the Federal Aviation Regulations, an effective quality control program must be applied to assure that the flightcrews are thoroughly knowledgeable with established policies and procedures and that compliance therewith is maintained. The failure of five successive flightcrews to test the CVR, the failure of two flightcrews to properly report a known malfunction, the failure of the captain of this flight to select airfoil anti-icing prior to descending through forecast icing conditions, his failure to inspect the reported accumulation of ice while on the ramp at Sioux City, his failure to require removal of the ice prior to departure, and his failure to select the proper power setting for this takeoff reflect **a** tendency of flightcrews to deviate from established procedures. An effective quality control program should have identified and corrected this tendency.

2.2 Conclusions

(a) Findings

1 The aircraft was properly certificated and maintained in accordance with current requirements, with the exception of the unreported malfunctioning CVR.

2 The crew was certificated and met the qualification criteria of current regulations.

3. There was no preimpact failure of the aircraft structure, systems, or powerplants.

4 The aircraft weight and balance was well within that allowed and within 189 pounds of that listed on the completed weight and balance form.

5. Icing conditions were accurately forecast.

6. The flightcrew should have reasonably expected to accumulate airfoil ice during the descent through the overcast approaching Sioux City.

7. The captain did not select airfoil anti-ice for the descent through the overcast.

8. The requirement for the use of airfoil anti-ice under these conditions was clearly outlined in the company operating manual.

9. The aircraft landed at Sioux City with an accumulation of airfoil ice.

10. The captain failed to have the aircraft deiced while at the ramp at Sioux City, although ground personnel advised him that ice was adhering to the aircraft.

11. The captain failed to recognize the aerodynamic penalties of airfoil icing. He did not personally check, or require his first officer to personally check, the ice accumulation on the aircraft, although he was advised of its presence.

12. The captain did not select the proper takeoff thrust required for the existing gross weight of the aircraft.

13. A stall occurred near the top of ground effect as a result of aerodynamic and weight penalties of airfoil ice accumulation.

14. The integrity of the cabin section, which was maintained throughout the impact path, prevented incapacitating injuries to the passengers.

15. The absence of fire was the critical factor in the success of this evacuation.

16. Injuries to the captain, first officer and forward stewardess denied the passengers fully effective and early leadership for the evacuation.

17. These injuries would most probably have been prevented by use of shoulder harnesses by the flightcrew and improved integrity of the forward stewardess seat.

18. If fire had developed, fire and emergency equipment would almost certainly not have been able to respond in sufficient time to have influenced the saving of lives.

(b) Probable Cause

The Safety Board determines that the probable cause of this accident was a stall near the upper limits of ground effect, with subsequent loss of control as a result of the aerodynamic and weight penalties of airfoil icing. The flightcrew failed to have the airfoil ice removed prior to the attempted takeoff from Sioux City. The Board also finds that the crew selected an improper takeoff thrust for the existing gross weight condition of the aircraft.

3. RECOMMENDATIONS

On October 22, 1969 the Chairman of the Safety Board submitted a letter to the Administrator of the FAA which described the successful evacuation of the passengers but noted that:

> The injuries sustained by three of the four crewmembers, however, prompts our concern as to the serious consequences that might otherwise be associated with the inability of crewmembers to assist evacuation under other less favorable circumstances. The existence of fire and smoke, for example, with resultant passenger confusion and panic, might have served to substitute a catastrophic occurrence for the successful evacuation that so fortunately was accomplished. All crewmembers should be cognizant of and attentive to their leadership responsibility and should make every reasonable effort to protect their physical well-being in order to assure that their assistance and guidance are available to their passengers in the event of an emergency.
>
> This accident serves to reemphasize a previous Board recommendation that flight crewmembers wear shoulder harness during all takeoffs and landings and, also, further substantiates your proposed amendment to FAR Part 121.311, "Seat and Safety Belts," contained in the recently issued NPRM No. 69-33 dealing with crashworthiness and passenger evacuation of transport category airplanes. Until the proposed requirement to utilize the shoulder harness is added to this part, however, we recommend the FAA make a directed effort to encourage all affected air carrier personnel to utilize this protective equipment.
>
> We also noted the proposed amendments to FAR Part 25.561 dealing with ultimate inertia forces. In view of the Ozark Air Lines accident, however, and the fact that this proposed amendment may not be applicable to presently certificated aircraft, we also recommend that the security and attachment points on the Douglas DC-9 forward stewardess seat be strengthened in order to reduce

the possibility of stewardess injury. Further we recommend that any potentially injurious environmental hazard resulting from protruding fixtures or equipment in the area of this seat be minimized by relocation or protective padding with high energy absorption material.

In a letter to the Chairman from the Administrator dated November 14, 1969, the Administrator advised that:

NPRM 69-33, issued August 12, 1969, proposes that Part 121.311 be amended to require crewmembers to wear their shoulder harness during takeoff and landing except when the crewmember cannot perform his required duties with his shoulder harness fastened. An an interim measure we are issuing an Air Carrier Operations Bulletin instructing all regional offices to strongly urge all operators to require their flightcrews to wear shoulder harness during takeoffs and landings. Crewmembers who could not perform their required duties with the shoulder harness fastened would be exempted from this requirement.

With regard to strengthening of the security and attachments of the stewardess seat, our investigation showed that the seat design and attachment complied with the strength requirements as specified in our Federal Aviation Regulations at time of aircraft certification. In view of the seat failure reported in the Ozark Air Lines accident we are continuing our investigations to determine the impact forces imposed on the seat and structural attachment and the need for corrective action. We will advise you of the results of this continuing investigation when it is completed.

We are not aware of any protrusions or hazardous equipment installed in the vicinity of the jump seat that might injure the stewardess under emergency landing conditions.

We would appreciate receiving further details concerning specific objects that caused the injuries to the stewardess in the Oaark Air Lines accident, and also whether her safety belt had been fastened.

On December 19, 1969, the Chairman of the Safety Board replied, advising that the stewardess' safety belt was fastened at the time of the accident. However, as a result of the seat failure, she struck the protruding handhold located adjacent to her seat thus sustaining injury. This handhold has been recessed on all *DC-9* aircraft subsequent to the model "Ten" series,

Subsequent to this accident, the company has taken action through increased emphasis during training and manual revisions to assure that the factors involved in this accident are fully understood by its pilot personnel.

In addition, through administrative line checks, the company has taken action to detect and correct any tendency of its flightcrews to deviate from established procedures.

BY THE NATIONAL TRANSPORTATION SAFETY BOARD:

/s/ JOHN H. REED
Chairman

/s/ OSCAR M. LAUREL
Member

/s/ FRANCIS H. McADAMS
Member

/s/ LOUIS M. THAYER
Member

/s/ ISABEL A. BURGESS
Member

September 2, 1970.

INVESTIGATION AND HEARING

1. Investigation

The Board received official notification of the accfdent at approximately 0830 c.s.t., on December *27*, 1968 from the Federal Aviation Administration. Prevailing weather conditions in the accident area delayed dispatch of the investigating team until 1415 c.s.t The investigator in charge, dispatched from Chicago, arrived at the scene at 1615 c.s.t. Weather conditions further delayed arrival of the team members dispatched from Washington, D. C. until 1100 c.s.t., December 28, 1968. Upon arrival, working groups were established for Operations, Witness, Weather, Flight Recorder, Cockpit Voice Recorder, Human Factors, Structures, Powerplants and Systems. Parties *of* interest participating in the investigation included Ozark Air Lines, Air Line Pilots Association, Douglas Aircraft Company, Pratt & Whitney Aircraft, Safe Flight Instrument Corporation, and the Federal Aviation Administration. The on-scene investigation was completed on January 10, 1970.

2. Hearing

A public hearing was not held in connection with the investigation of this accident.

Crew Information

Captain Patrick G. Sweeney, aged 48, was employed by Ozark Air Lines, Inc., March 19, 1955. He held Airline Transport Pilot Certificate No. 156331, with ratings in the Douglas DC-3, Martin 404, Fairchild F-27 and the Douglas DC-9 Aircraft.

He passed his last examination for a Federal Aviation Administration first class medical certificate on December 17, 1968, with the limitation noted: Correcting glasses for near vision. He had accumulated 19,145 hours'total flight time, of which 392 hours were accumulated in the preceding 6 months, 171 hours in the preceding 90 days, 53 hours in the preceding 30 days and 5 hours in the preceding 24 hours. He had acquired 63 total hours in the Douglas DC-9. Initial ground training in the Douglas DC-9 was commenced on June 3, 1968, and completed on June 21, 1968. Flight training in this aircraft was commenced on June 24, 1968, and interrupted because of scheduling requirements on June 26, 1968, after 5 hours'flight time. He then completed 3 hours' ground school refresher on September 30, 1968. recommenced flight training on October 1, 1968. He obtained his Douglas DC-9 type rating on October 14, 1968, at which time he had accumulated 18 total flight hours in the Douglas DC-9, including his type rating flight.

First Officer John T. Schmeltz, aged 33, was initially employed by Ozark Air Lines, Inc., on February 1, 1962. Because of a break in employment, his date of seniority was June 15, 1964. He held Airline Transport Pilot Certificate No. 1434911, with ratings in the Douglas DC-3.

He passed an examination for a Federal Aviation Administration second-classmedical certificate, without limitations, on January 18, 1968. He had accumulated a total of 6,048 total flight hours, of which 390 hours were acquired in the preceding 6 months, 171 in the preceding 90 days, 32 in the preceding 30 days, and 5 hours in the preceding 24 hours. A total of 20 hours were acquired in the Douglas DC-9.

First Officer Schmeltz initially commenced Douglas DC-9 ground school on June 3, 1968, which was completed with the exception of the final examination. As he was not needed in scheduled service on the DC-9 at this time, he was given 12 hours'refresher ground school in addition to procedural training on November 6 through November 10, 1968. He commenced DC-9 flight training on November 16, 1968, which was completed on November 20, 1968. At the time of completion of flight training, he had a total of 7 hours in the DC-9, which included his first officer's check.

Both crewmembers had two rest periods during the 24-hour period prior to this flight. One was from 1211 to 2035 on December 26, 1968, and the second was from 0026 *to* 0525, for a total *of* 13:23 hours.

Stewardess Trudy Roybal, aged 22, was employed by Ozark Air Lines, Inc., on February 13, 1967, and received her last recurrent training on April 26, 1968.

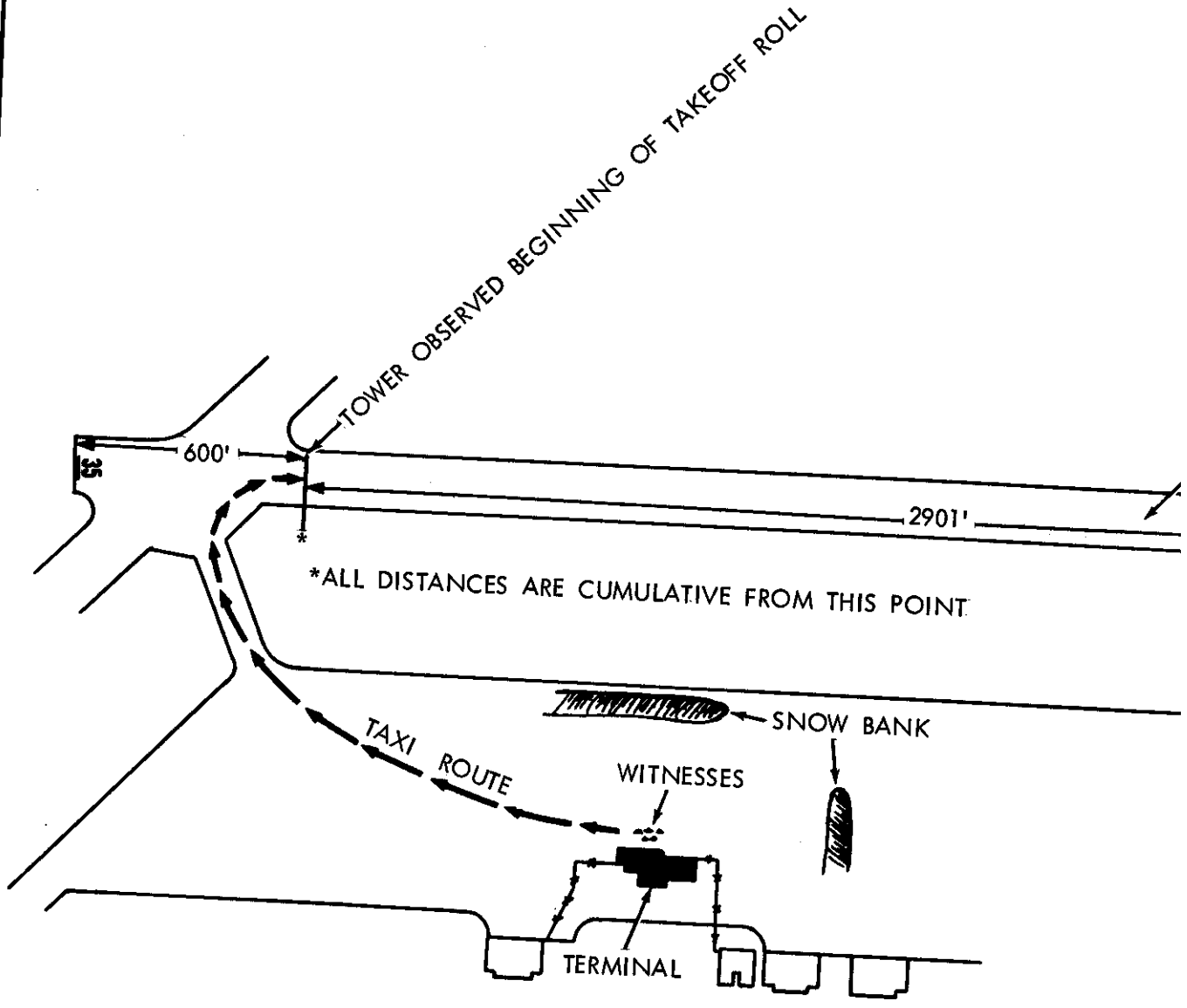
Stewardess Kathy King, aged 20, was employed by Ozark Air Lines, Inc., on February 1, 1968, and received her last recurrent training on April 24, 1968.

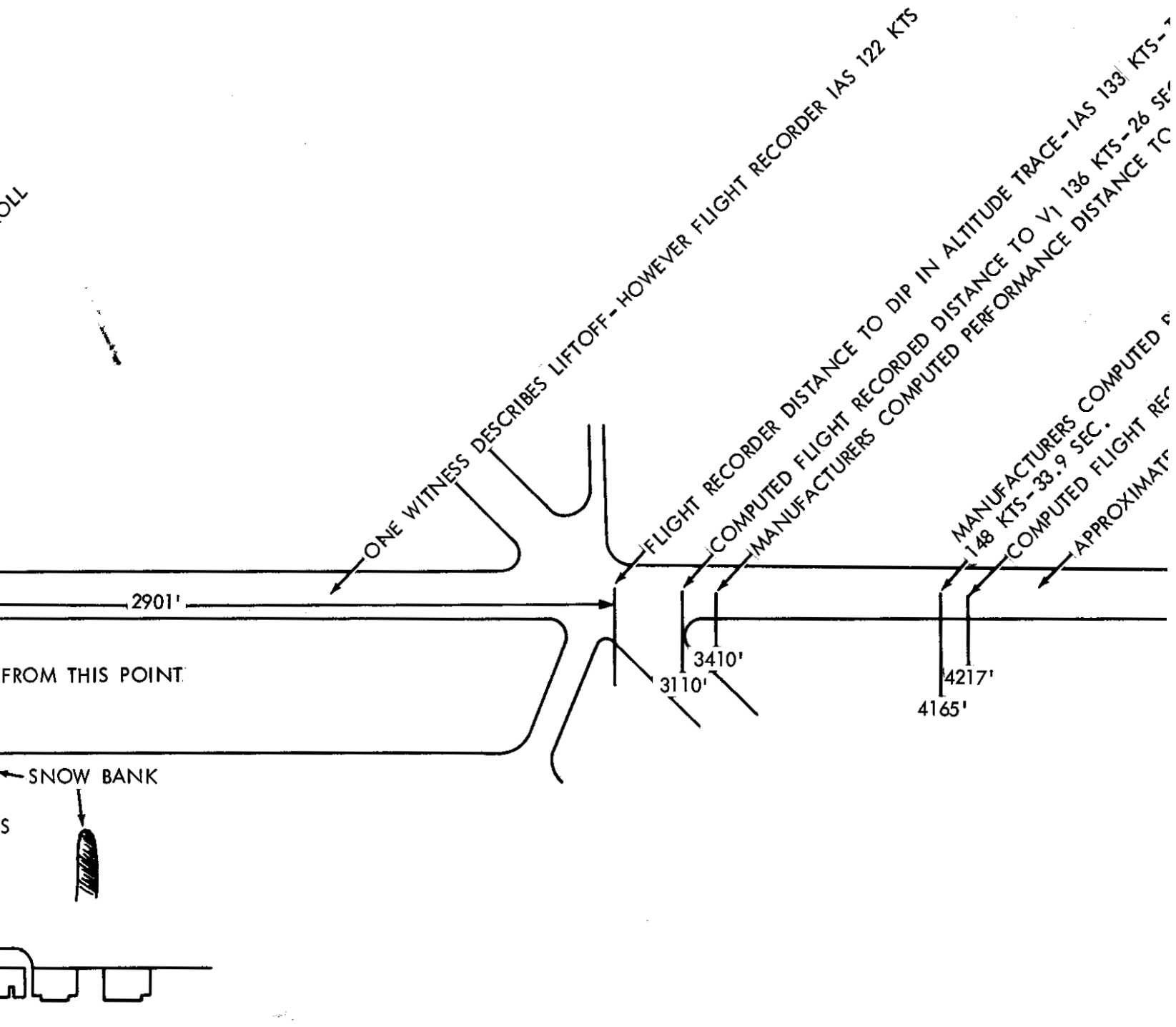
Aircraft Information

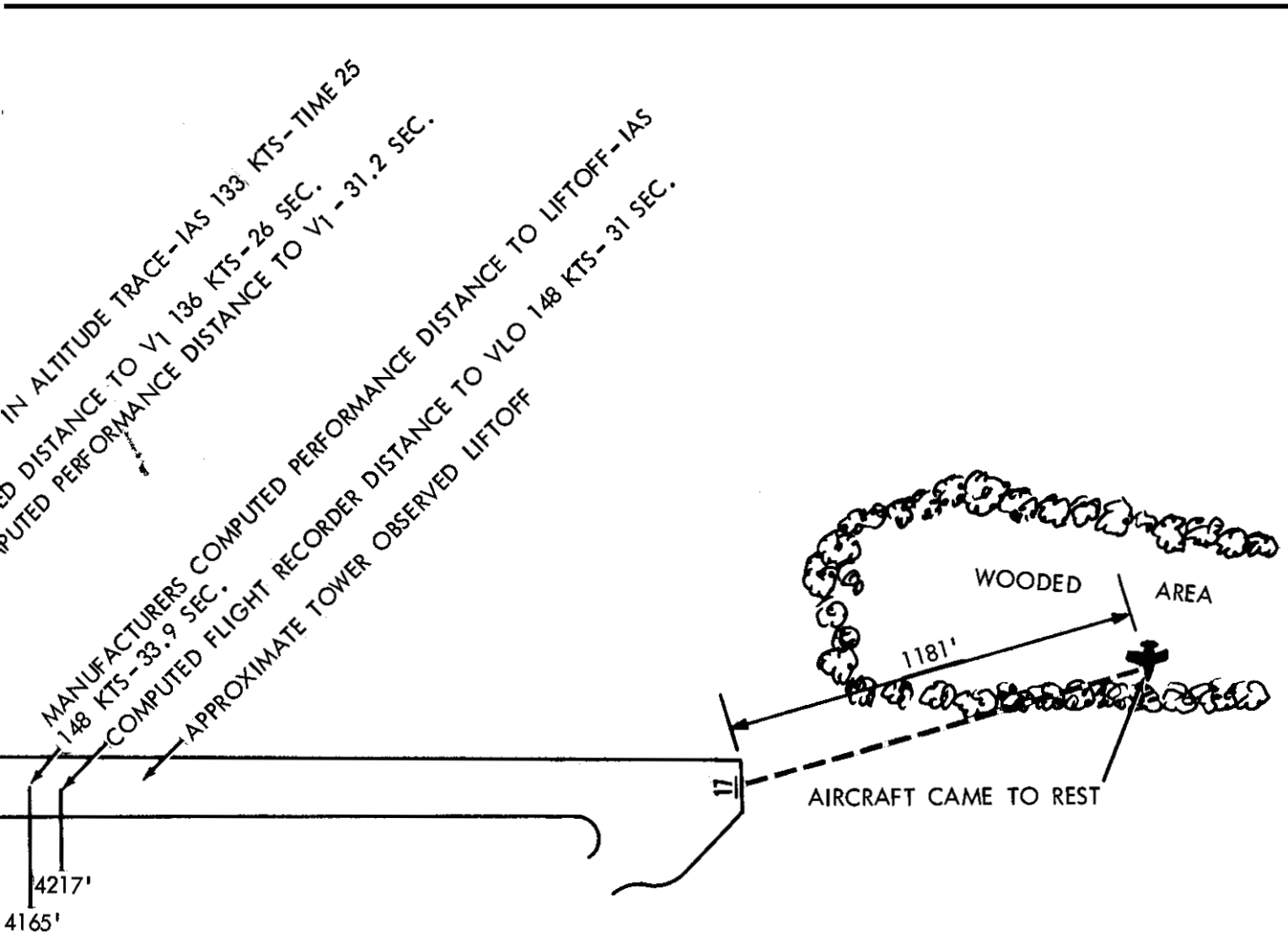
Douglas DC-9-15, N974Z, S/N 47034, registered to Ozark Air Lines. Inc., was manufactured on August 30, 1967, and, at the time of the accident, had accumulated a total airframe time of 3458:09 hours. It had been, flown 187:41 hours since the last major inspection. A turnaround, line maintenance inspection was completed prior to origination of the flight from Sioux Falls, South Dakota.

The aircraft was equipped with two Pratt & Whitney model JT8D-7 engines. The engine serial numbers, time since overhaul, and total time are as follows:

SERIAL NUMBER	TIME SINCE OVERHAUL	TOTAL TIME
Engine No. 1 L P657291D	Never Overhauled	1299:17
Engine No. 2 R P656972D	" "	2876:20


TOWER OBSERVED BEGINNING OF TAKEOFF ROLL
35
600'
2901'
*ALL DISTANCES ARE CUMULATIVE FROM THIS POINT
SNOW BANK
TAXI ROUTE
WITNESSES
TERMINAL


ONE WITNESS DESCRIBES LIFTOFF - HOWEVER FLIGHT RECORDER IAS 122 KTS
FLIGHT RECORDER DISTANCE TO DIP IN ALTITUDE TRACE - IAS 133 KTS -
COMPUTED FLIGHT RECORDED DISTANCE TO V1 136 KTS - 26 SE
MANUFACTURERS COMPUTED PERFORMANCE DISTANCE TO
MANUFACTURERS COMPUTED
148 KTS - 33.9 SEC.
COMPUTED FLIGHT REC
APPROXIMAT
2901'
FROM THIS POINT
3110'
3410'
4165'
4217'
SNOW BANK



NATIONAL TRANSPORTATION SAFETY BOARD
DEPARTMENT OF TRANSPORTATION
Washington., D.C.

TAKEOFF ACCELERATION CHART
OZARK AIRLINES INC., DC-9, N974Z
SIOUX CITY, IOWA
December 27, 1968