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# Aircraft Accident Report - Continental Air Lines, Inc., Boeing 727-224, N32725, Tucson, Arizona, June 3, 1977

U.S. National Transportation Safety Board, Washington, D C

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16. Abstract

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The National Transportation Safety Board determines that the probable cause of the accident was the captain's decision to take off under evident hazardous wind conditions which resulted in an encounter with severe wind shear and subsequent collision with obstacles in the takeoff path. The rate of climb of the aircraft in these conditions when flown according to prescribed operating procedures was not sufficient to clear the obstacles. However, if the aircraft's full aerodynamic capability had been used, collision with obstacles probably could have been avoided.

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TABLE OF CONTENTS

NATIONAL TRANSPORTATION SAFETY BOARD
WASHINGTON, D.C. 20594

AIRCRAFT ACCIDENT REPORT

Adopted: August 1, 1978

CONTINENTAL AIR LINES, INC.
BOEING 727-224, N32725
TUCSON, ARIZONA
JUNE 3. 1977

SYNOPSIS


About 1258 m.s.t. on June 3, 1977. Continental Air Lines, Inc., Flight 63 struck powerlines and two utility poles just after takeoff from runway 21 at the Tucson International Airport, Tucson, Arizona. The aircraft was damaged substantially after striking the powerlines and utility poles. which were located about 130 feet to the left of the runway centerline and about 710 feet from the departure end of the runway. The aircraft was landed safely at the Tucson Airport; there vere no injuries.

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## 1. FACTUAL INFORMATION

### 1.1 History of the Flight

On June 3. 1977. Continental Air Lines, Inc., Flight 63, a Boeing 727-224 (N32725), operated as a passenger flight from Houston, Texas. to Los Angeles, California, with scheduled en route stops at San Antonio and El Paso, Texas, and at Tucson and Phoenix. Arizona. A crew change was made in El Paso.

Before the flightcrew started the engines, the Tucson station agent had prepared the Pilot Weight Sheet (weight and balance form) for Flight 63. The sheet was prepared for a 15° flap takeoff on runway 11L, the active runway at the time, and was Eased on a 95° F temperature and a takeoff gross weight of 137.960 lbs. Before leaving the gate, the flightcrew received a wind report of 210° at 18 kns. gusting to 25 kns, and the second officer prepared the takeoff data card ior a runway 29R departure. The computed takeoff speeds were as follows: Critical engine failure speed, or decision speed ($V_1$), and rotation speed ($V_R$) were 123 kns; takeoff safety speed ($V_2$) was 138 kns. Before beginning taxi, runway 21 was selected instead of runway 29R, because it was then the current active runway ..d the wind velocity exceeded the crosswind limits for runway 29R.

Flight 63 departed the gate at 1251 1/ with 84 passengers and 7 crewmembers aboard. It was cleared to taxi to runway 21 for takeoff. During taxi operations. the second officer computed the weight for a runway 21 departure and advised the captain. "Well, we're ovcrgrossed without wind." He further advised that they needed 10 kns of headwind to meet takeoff weight requirements. *(See* Appendix C.) While Flight 63 was en route to runway 21, the tower controller transmitted the following wind reports: At 1251:35, 180° variable to 210' at 20 kns, gusting to 32 kns; at 1254:10, 210" at 40 ins; 3t 1256:00, 210' at 30 kns, gusting to *50* kns; at 1257:05, 150' variable to 240° at 25 kns, gusting to *35* kns; at 1257:20, 120' at 13 kns; and at 1257:40, 170' at 13 kns. This last reported wind would have provided a 10-kn headwind component at the start of the takeoff roll on runway 21.

During the tasi to runway 21, a dust storm passed over the airport and reduced the visibility. The flightcrew first recognized this dust storm at 1251:38 when the cockpit voice recorder (CVR) recorded a discussion between crewmembers concerninp, the airport's going IFR because of blowing dust. The dust storm lasted for about h minutes. During that time, the flightcrew experienced dilficulty in following the taxi route to the runway. At 1254:30 the Flight was told by the tower to make "a right turn onto the next taxiway." At 1254:35 the firs: officer of Flight 63 replied. "Okay, we got to find it first." According to the CVR, at 1255:06 the captain said, "This is just a short lived thing, hy the tine we get out there, it will be all gone I think." At 1257:05, the flight was cleared for takcofl on runway *21*. At 1257:15 the first officer replied, "Oh sixty-three, we're gonna okay looks like we cnn get into position now. We haven't even been able to get into position." At 1257:35 the flight requested takeoff clearance. At 1257:40 the tower cleared the flight for takeoff. The takeoff was begun from the position on the runway where taxiway C intersects the runway and *6,500* ft of runway rennin. hlthough the captain and first officer referred to the Jeppesen airport diagram, they indicated that they did not *see* the displaced threshold depiction. The captain later stated that he had not been into the Tucson Airport for about 3 years before the day of the accident.

1/ All times herein are mountain standard tine, based on the ?$-hour clock.

i

For the takeoff, the captain stated that he used normal takeoff thrust (1.94 EPR on engines Nos. 1 and 3 and 1.96 EPR on engine No. 2) and a 15° flap setting. He farther stated that all instrument readings were within takeoff limits when checked at 80 kns even though the No. 1 engine had been slow to reach takeoff power. At 1258:22 the captain stated "Hang on guys." At 1258:24 an unidentified crewmember stated "lost all our airspeed." At 1258:26 an unidentified crewmember stated "keep it going." At 1258:28 the first officer called "$V_1$ rotate," and the captain rotated the aircraft to a reported pitch attitude of about 11°. At 1258:33 the first officer stated "dropped off on us." The captain later testified "as we rotated nothing happened. It seemed like quite a long time before we were getting off the runway at all. We assumed we were just slightly off the runway. When I noted that we weren't climbing, I glanced at the airspeed again and noticed that we were slightly above $V_2$. I increased the pitch attitude above the normal takeoff climb and again noted no climb. Then I noted the airspeed dropping off rapidly. I then also observed the wires and that we were going to hit the wires. I decreased the nose attitude to the normal pitch attitude for takeoff and applied full power." He said that he lowered the nose because he was concerned with "control." The captain stated that he did not consider aborting the takeoff at any point on the takeoff roll.

The aircraft struck powerlines and two utility poles, the first of which was located 710 ft from the departure end of the runway. Initial impact was recorded on the CVR at 1258:41. The flight data recorder (FDR) trace showed that in the 5 to 6 secs before the aircraft hit the wires, the indicated airspeed varied from about 145 kns to 130 kns. The FDR showed that after the aircraft struck the poles, it then accelerated normally through 150 kns. At 1258:50 the first officer advised the tower, "Okay sixty-three we got the wires, we're gonna be airborne, we're gonna make it."

Once safely airborne, after an evaluation of aircraft flight characteristics, the crew informed the tower that they were going to return and land; a normal landing was made on runway 29R about 1310:20. Regarding the takeoff wind conditions, the captain said that "noting the conditions that I was taking off under, I wanted to use all of the available runway, and I made a point in my mind, as I was taxiing, to go over the bar crossing the runway and to get as much available runway as possible for takeoff." The captain stated that when the flight landed at Tucson the "first officer was flying and he landed on 21." The captain did not recall seeing the displaced threshold area during the landing. With regard to training that he may have received on runway markings, the captain stated that he was "not sure that it was covered."

The flightcrew stated that before beginning the takeoff, each saw a windsock at the approach end of runway 21. The windsock was indicating a wind of within 10° of the runway heading and was "straight out."

The captain stated that before takeoff, he vas concerned about the high gusty winds and the dust that vas blowing. and "since I vas already taxiing at that time. I decided to wait and see and continue taxiing. As the dust storm passed. I could see out my left vinaov and it was clear.... It appeared that everything vas back to as before." The captain stated that he did not anticipate the possibility of a wind shear because "my previous cxperiencc with wind shear is that the winds are quite variable. as much as 180° and, as far as I am concerned at :his time. the wind was predominantly out of the southwest ...."

The captain of Air West Flight 985. scheduled to depart at 1305, delayed his departure from the gate because of the dust and winds. He said he told the gate agent, when he came onboard to give the crew the weight sheet, that "if it was alright with him. I vould just as soon wait a few minutes until the thing kind of blcv over."

The accident occurred during daylight hours at 32°07'07"N latitude and 110°56"36'W longitude and at an elevation of about 2,660 ft m.s.l.

1.2 Injuries to Persons

| Injuries | Crew | Passengers | Other |
|---|---|---|---|
| Fatal | 0 | 0 | 0 |
| Serious | 0 | 0 | 0 |
| Minor/none | 7 | 84 | 0 |

1.3 Damage to Aircraft

The aircraft was damaged substantially.

1.4 Other Damage

Two utility poles and several sections of powerline were destroyed.

1.5 Personnel Information

The seven crewmembers were properly certificated for the flight in accordance with Federal Aviation Administration (FAA) requirements, except for the flight captain who vas not route certified. (See Appendix B.)

1.6 Aircraft Information

The aircraft was certificated, equipped. and maintained in accordance vith FAA requirements. (See Appendix C.)

According to the Pilot Weight Sheet, the aircraft's takeoff gross weight vas 137,960 lbs, 960 lbs over takeoff gross veight limits for a no-wind condition for runway 21. At 137.960 lbs takeoff gross weight, a 3.6-kn headwind was required to raise the allowable gross weight limit so that the takeoff gross weight would be within prescribed limits. (See Appendix D.)

The center of gravity was within prescribed limits. The aircraft had about 18.900 lbs of Jet A fuel on board.

The flight engineer's calculated gross weight was approximately 1,000 lbs heavier than that calculated by the station agent. The flight engineer stated he was aware at the time that his calculation of fuel on board was 700 lbs higher than the station agent's calculation. and that his rule-of-thumb for empty aircraft gross veight was arbitrarily 300 lbs high. His calculations led him to conclude that the flight needed a 8.8-kn headwind to be within prescribed takeoff weight limits. A 20-kn headwind was needed for takeoff from runway 21 using 6,500 ft of runway. The Safety Board used the station agent's weight calculations in the performance studies.

## 1.7 Meteorological information

The National Weather Service (NWS) surface weather observations at the airport were:

1154 — 9,000 ft scattered, 14,000 ft scattered, estimated 25,000 ft overcast. visibility--50 mi, temperature--95° F, dewpoint--40° F, wind--270° at 11 kns, altimeter setting--29.89 in. cumulonimbus over mountains, northeast. southeast, and southwest. Remarks--rainshowers, intensity unknown, southeast and southwest. Lightning cloud to ground, southeast.

1253 — Estimated 9.000 ft broken, 14,000 ft broken. 25,000 ft overcast, visibility--60 mi weather--light rainshowers. temperature--92° F, dewpoint--38° F, wind--210° at 21 kns gusting to 34 kns, altimeter--29.90 in., remarks--blowing dust west-southwest rain began 1225. Peak wind 220° at 34 kns at 1253.

1310 — Estimated 9,000 ft broken, 17,000 ft broken, 25.000 ft overcast. visibility-40 mi, weather--thunderstorms with light rainshower, temperature--90° F, dewpoint--38° F, wind--310° at 10 kns gusting to 22 kns, altimeter setting--29.90 in., remarks--thunderstorms west and north began 1305.

The NWS terminal forecast for Tucson. which was issued at 0840 and which was valid for the 24 hrurs after 0900, was as follows:

1300 Clouds 8,000 ft scattered variable broken; 1500: Ceiling 8,000 ft broken chance of visibility reduced to 3 mi with thunderstorms, light rainshowers, blowing dust. and wind gusts to 35 kns.

The anemometer that provides the official surface wind information is located about 2.500 ft northeast of the intersection of runway 29/11 and runway 21/03.

At the time of the accidrnt. the following wind warning was in effect for the Tucson arm hut had not been transmitted to the tower:

> Scattered thunderstorms in the Tucson area may produce some wind gusts to about 40 to 55 mph this afternoon and evening along with brief blowing dust lowering visibilities to less than a mile. Precipitation will be spotty and generally light. Caution is advised when blowing dust is visible as wind gusts may he quite strong nearby.

The warning was issued at 1245 by the NWS office on the airport. The tower did not receive the wind warning information until 1309. Thr weather observer stated that transnittal tc the tower anu other facilities was delayed because of the rush of events and other priorities.

The Continental Air Lines forecast fur Tucson, valid for 16 hours aftcr 1100, was in part as follows: Ceiling and visibility above 5,000 ft, 4 mi wind variable--5 kns, cumulonimbus in vicinity. chance of ceiling 4,000 ft overcast. visibility- 6 mi with thunderstorms and light rainshowers. wind gusts to 30 kns.

An Air National Guard pilot, who was locatrd in a runway supervisory unit at the rnd of runway 11L, stated that from 1215 until 1300 the winds were variable from the southwest to the northwest at 10 to 30 kns. W further stated that wind speed and direction differed between the two runway supervisory unit; at each end of runway 29R. At 1255 he noticed virga. streaks of precipitation which evaporated hefore reaching the ground. in must quadrants and a circular wall of dust novc over the airport from the southwest. About this tine he noticed Flight 63 on takeoff.

Another Air National Guard pilot, who had taxied an aircraft down taxiway "A" tu the intersectior of runway 29R and 21 and was waiting at the intersection to cross the runway when Flight 63 took off, stated that "the blowing dust was visible in front of me as I began my taxiing down the parallel taxiway. Its point of origination at that tine was 1 to 2 mi southwest of my position. The point of origination moved across the airport in front of me so that it was visible just north of the airport as Continental departed." He further stated "as the .aircraft broke ground it yawed abruptly to the right as (if) it had weathervaned into the wind. Simultaneously with the weathervaning, the aircraft moved laterally to its left a distance of 50 to 100 ft."

Two firemen, who were located about 1,500 ft north of the intersection of runways 29/11 and 21/03, said that when Flight 63 passed the runway intersection, a windsock located near the intersection indicated no wind. The crew did not see this particular windsock.

About 15 min before Flight 63's departure, ... ver controller had advised several general aviation aircraft, before takeo... of a possible wind shear at the departure end of runway 21. This advisory was discontinued when no comments were received from the departing aircraft.

## 1.8 Aids to Navigation

Not applicable.

## 1.9 Communications

Before the accident, communications were normal; however, after the powerlines and utility poles were hit, tower communications were disrupted briefly because electrical power was lost and standby equipment had tu be used.

## 1.10 Aerodrome and Ground Facilities

Tucson International Airport is located about 4 1/2 mi south of Tucson, Arizona. Two runways were available for takeoff -- runway 11L/29R and runway 03/21. Runway 11L/29R is 12,000 ft long and 150 ft wide. Runway 03/21 is 7,000 ft long and 150 ft vide. Although there is a 500-ft displaced threshold for landing, the entire length of the runway is available for takeoff. Taxiway "C" intersects the runway 500 ft down the runway from the approach end. In order to use the entire 7,000 ft, one must backtrack down the runway. (See Appendix E.) Airport elevation is 2,630 ft m.s.l. The displaced threshold area of runway 21 was marked with 120-it lung, yellow arrows followed by a row of chevrons end a 10-ft-wide white displaced threshold stripe followed by 60-ft-long runway numbers. (Standard displaced threshold runway marking depicted in the Airmen's Information Manual.)

## 1.11 Flight Recorders

N32725 was equipped with a Fairchild model 5424 flight data recorder, serial No. 5759, and a Sundstrand model C-557 cockpit voice recorder. The two recorders were located in the aft section of the fuselage. Neither of the recorders were damaged in the accident; FDR traces and CVR channels were recorded clearly. The quality of the CVR recording was good and the entire tape was transcribed.

The FDR readout began at a point where the aircraft turned onto the runway to begin the takeoff and ended at a point where the aircraft had climbed to an altitude of about 4,200 ft m.s.l. The altitude trace and heading trace times were stable until the aircraft lifted off. At that time the recorder data trace showed an 8° heading change to the right. The altitude trace showed a slight climb aiter liftoff followed by a slight descent after impact and then a normal climb profile.

The recorded airspeed increased erratically from zero to 110 kns (13 kns below $V_1$) and then fluctuated around 110 kns for about 12 secs before increasing. Eight secs before the "$V_1$ rotate" call, the recorded airspeed dropped to 94 kns. at 4 sec before $V_1$ it recovered to 114 kns. Four secs after the "$V_1$ rotate" call, the airspeed reached about 142 kns, then began to decrease to nbcut 130 kns at impact. After the aircraft.struck the utility poles. its airspeed rapidly increased to about 156 kns then increased slowly to the highest airspeed recorded-- 185 kns — during the climbout. (See Appendix F.)

1.12 Wreckage and Impact Information

The aircraft first struck a utility pole 710 it from the departure end of runway 21 and 95.5 fc to the left of the runway centerline. Next, it struck a utility pole 887.2 ft from the departure end of runway 21 and 153.8 ft to the left of the runway centerline. Both utility poles were 39 ft high. Parts of the two poles and the powerlines were scattered along the aircraft's flightpath. and pieces of the pules were embedded in the aircraft's structure.

The aircraft remained intact. The right and left vines. the lower fuselage. and the landing gear doors were heavily damaged. The lower left wing surface and the entire length of the leading edge flaps exhibited electrical arcing hurns. The lower wing had been punctured in several places with accompanying internal wing damage and fuel leakage. The leading and trailing edge flaps had been punctured and dented.

The right wing had been severelv dented and punctured near the leading edge flaps and slats, and minor abrasions were found on the lower wing surface. On the lower fuselage, water and fuel drain masts and an antenna were sheared off. In addition. several wing fairings were dented.

On the left main landing gear, a gear door was severed and on the right main landing gear, a door was bent. Antiskid wiring was also damaged in the accident. The landing gear was stili in the extended position at imapct.

1.13 Medical and Pathological Information

A review of the flightcrew's medical records revealed no evidence of medical problems that night have affected their performance. Kone of the aircraft's occupants were injured in the accident.

1.14 **Fire**

There was no fire.

1.15 Survival Aspects

The accident was survivable. There was no damage to the interior of the aircraft. Before the landing, airport fire and rescue equipment was alerted and positioned near the runway. After a normal landing, the captain taxied the aircraft clear of the runway onto **a** highspeed taxiway where the engines were **shut** down. The fire department applied extinguishing agent to the wings as a precautionary measure. The passengers deplaned via a boarding ramp after it was determined that an emergency evacuafion was not required.

1.16 Tests and Research

The information from Flight **63's FDR** was analyzed to determine: (1) the probable winds into which the aircraft flew, and (2) whether the aircraft could have successfully cleared the utility poles during the takeoff.

Characteristics of the Atmosphere

Theoretical aircraft performanct was compared with actual aircraft periormance as recorded on the FDR. The difference was assumed **to** reflect the effect **of** external forces on the aircraft. Since all aircraft systems, including engines and flight controls, were operating properly, differences between actual performance and theoretical performance we-e assumed to reflect the effects **of** winds.

The horizontal wind component in the direction **of** the takeoff **run** was determined by taking the difference between the known performance capability **of** the aircraft (groundspeed as calculated from **an** integration of the acceleration capability **of** the aircraft), and the actual performance of the aircraft (indicated airspeed as determined from the FDR trace).

The horizontal wind component from liftoff to the time of impact was obtained in a similar manner by comparing calculated groundspeed with airspeed from the **FDR.** The acceleration, relative to tho ground after liftoff, used to calculate groundspeed was determined using the rate of climb/acceleration capability **of** the aircraft in ground effect (empirical data) and the rate of climb required for Flight 63 to hit the utility poles in the time interval from liftoff.

**The** brake release point was assumed to be ***650*** ft from the approach end **of** the runway based on comments from the flightcrew and runway and taxiway geometry. The probable liftoff point, based on Boeing ***727-224***

acceleration data, wds calculated to have been after 5,450 ft of takeoff roll. The point of impact was interpreted from the FDR to have been at the time of the vertical acceieiration spike of 0.26, 65.04 secs from the beginning of the readout. (See Appendix F.)

Two levels of thrust were assumed during a normal takeoff in the study: (1) Average thrust--the thrust normally expected from three average engines, and (2) minimum thrust--the minimum certified thrust, as used to calculate the performance section of the aircraft flight manual, is the minimum level of thrust guaranteed by the engine manufacturer. The wind models derived were identical for both cases.

Three techniques for setting takeoff power were examined:

(1) Set the brakes, advance the power to about 1.4 EPR, release the brakes. and set takecff EPR during the takeoff roll.

(2) Set the brakes, advance the power to takeoff EPR. release the brakes.

(3) When entering the runway. continue rolling and set the takeoff EPR during the roll before reaching 80 kns.

None of the three methods influenced takeoff performance significantly.

The plot of the derived horizontal winds indicated that the aircraft encountered a headwind component of more than 40 kns at the beginning of the takeoff roll. This headwind component decreased to essentially zero at a point about ha'f way down the runway. From that point the wind experienced by Flight 63 changed to a tailwind that averaged about 5 kns until liftoff. After liftoff, the tailwind increased at a rate of about 4.5 kns/sec to a maximum of about 28 kns at the first utility pole.

Since crosswind could only be estimated from the heading change recorded on the FDR, a right crosswind was assumed with a speed increasing linearly from zero at brake relfase to about 30 kns at impact.

The FDR data indicate that just after impact the aircraft apparently encountered an abrupt shift in winds which permitted it to assume a near normal acceleration schedule.

The derivea wind model contained only headwind/tailwind and crosswind components. Investigators believed that at 30 ft a.g.l. vertical wind velocities would be negligible. The presence of relatively high horizontal winds supported this assumption.

## Takeoff Performance

In order to determine whether the aircraft could have cleared the utility poles during the takeoff, the required rate of climb was calculated for two flight profiles:

> (1) Average rate of climb required to miss the utility poles from the point at which it was realized that obstacle cleatance would be a problem; and (2) the average rate of climb provided hy sustaining the highest probable pitch attitude reached by Flight 63 after liftoff.

In the first case, it was determined that when obstacle clearance became a concern, the angle of attack could have been increased to temporarily establish a steeper flightpath and clear the utility poles. Assuming that a decision was made by the pilot at a point about 710 ft from the obstacle and 20 ft above the ground at an initial airspeed of 135 kns indicated airspeed (KIAS), the average rate of climb required to clear the obstacles by 20 ft in no-wind conditions would have been 780 ft/min. If flown in winds identical to the derived wind profile, the average rate of deceleration at 780 ft/min rate of climb would have been about 2.2 kns/sec. (See Figure 1.) Thus, the airspeed above the obstacle would have been about 128 KIAS (13 KIAS above the stickshaker activation speed) and an estimated pitch attitude of at least 13° would have been required.

In the second case, it was calculated that if the highest pitch attitude reached after liftoff had been sustained, the aircraft would have cleared the obstacle. FDR data and pilot testimony indicated that pitch attitude was reduced shortly after takeoff when a drop in airspeed was noted. This probably occurred about 15 ft a.g.l. According to the captain, the initial target pitch attitude was about 11°. The FDR data indicate that the airspeed was decreasing through an airspeed of about 138 KIAS when the pitch attitude was reduced. It was determined that if the aircraft had reached and had maintained the 11° pitch attitude, it would have accelerated at an average rate of about 2.6 kns/sec. With a tailwind increasing at 4.5 kns/sec per the derived wind profile, airspeed would have been decreasing through about 125 KIAS at the utility poles and the aircraft would have been at an altitude of about 70 ft a.g.l. At Flight 63's takeoff configuration, the stickshaker would have activated at 115 KIAS and a stall would have occurred about 106 KIAS.

Significantly, the calculations for these two cases assumed that the wind effect on the aircraft, derived from the FDR data, did not change as altitude increased. There are several schools of thought regarding the wind velocities at altitude in the vicinity of thunderstorms. The best evidence indicates that vertical wind speeds associated with thunderstorm downdraft activity diminish rapidly below 300 ft and that the direction of movement changes to a horizontal outflow.

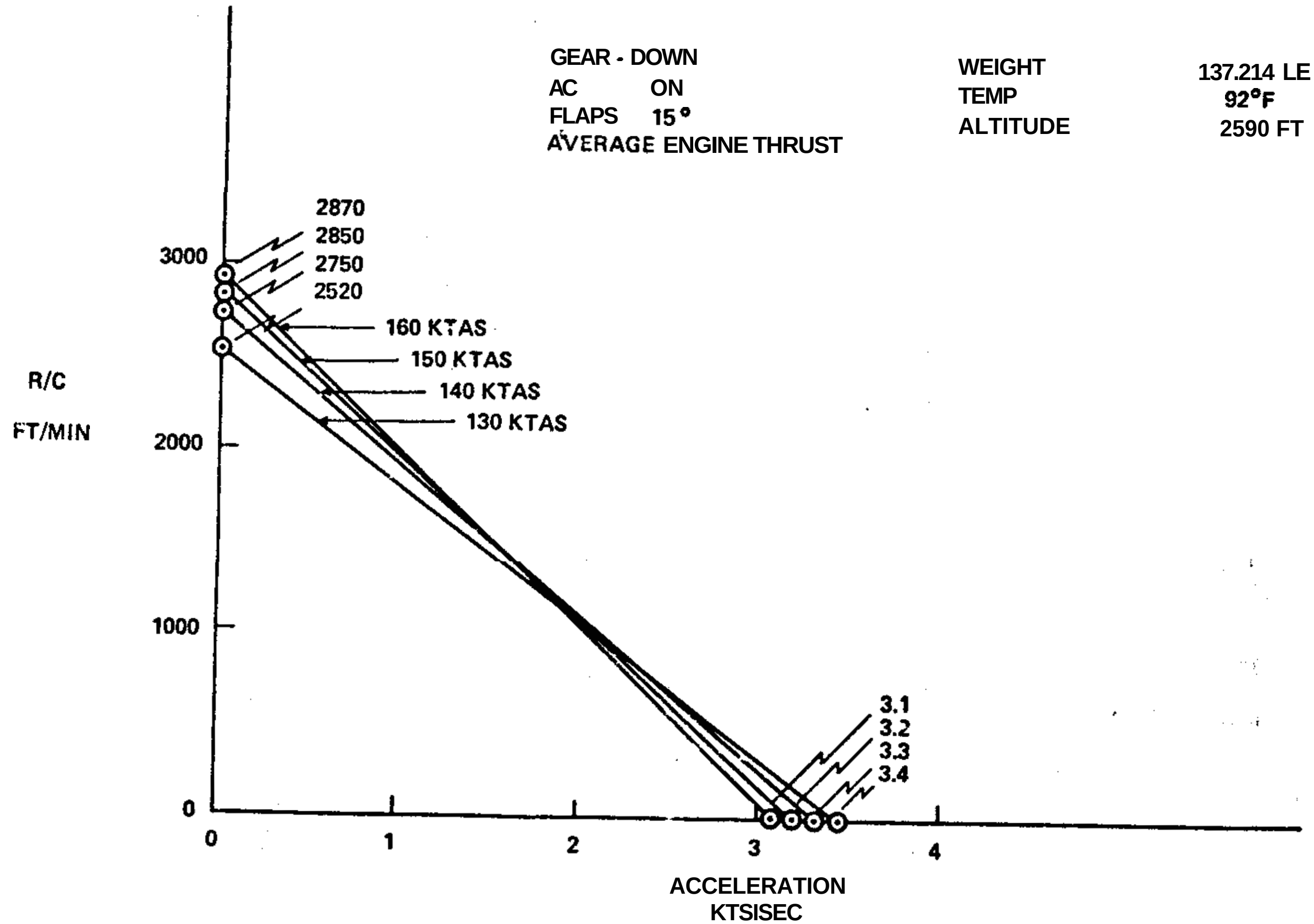


Figure 1. Acceleration vs rate of climb in ground effect Boeing 727-224.

Although the Board does not believe there were significant vertical winds affecting Flight 63 at 30 ft a.g.l., additional calculations were performed to explore the possibiiity that Flight 63 could have successfully flown through an even more severe total wind effect than that recorded by the FDR. Calculations were made for the two flight profiles previausly desrribed in which, in addition to the total wind effect recorded by the FDR, (assumed to be all horizontal winds). strong ,vertical downdrafts were also assumed to be present.

Using vertical wind speed data derived from-recent NASA and National Severe Storms Laboratory studies, an extreme vertical wind profile was selected consisting of a linear decay of the vertical speed from 990 ft/min at 60 ft to zero at the surface. The actual decay would more likely resemble a less severe logarithmic functiau Additionally, it should be noted that the data from which this mode?. was derived represented worst case instantaneous values, not average values.

In the first case, in which it was assumed the angle of attack could have been increased to temporarily establish a steeper flightpath, an average rate of climb of 1.400 ft/min would be required to counter the downdraft and clear the powerlines by 20 ft. This rate of climb would require a steady, smooth rotation to near the stickshaker attitude of about 15° - 16° (depending on maneuvering loads and airspeed). If initiated at an airspeed of 135 KIAS the airspeed over the powerlines would be about 120 kn.

In the second case, in which it was assumed the highest angle of attack reached by Flight 63 was maintained, it is estimated that a sustained pitch attitude of about 14' would be required to clear the powerlines by about 26 ft. The airspeed over the powerlines at such an attitude would have been about 119 kns.

Because the captain initiated the takeff with 6,500 ft of runway remaining rather than from the end of the 7.000 ft runway, the Board attempted to determine what effect the additional 500 ft of runway would have had on the flight's ability to clear the obstacle. Since the wind model derived from FDR data reflects the total wind along the flight profile actually flown by Flight 63, the Board was unable to determine what winds Flight 63 would have experienced had the flight taxied to the end of the runway and used all of the available runway for takeff. However, assuming that the winds did not change from those of the FDR-derived wind model, a takeoff initiated from the end of the runway,. rather than from the displaced threshold, would have resulted in liftoff at a point 2,180 ft from the powerlines (550 ft before the actual liftoff point). In this case, at an average groundspeed of 138 kns (230 ft/sec), the time elapsed from liftoff to the oowerlines would have been about 9.5 sec. The rate of climb required to clear the 39-ft utility poles hy 35 ft would have been about 467 ft/min and in the existing wind conditions, the airspeed would have decreased to about 121 kns.

*Rejected Takeoff Performance*

The stopping capability of the B-727 was analyzed to determine when the takeoff could have been rejected and the aircraft stopped on the remaining runway. In the wind conditions derived from the FDR data, it was estimated that the aircraft could have been stopped on the runway if the decision to reject the takeoff had been made with at least 2,200 ft of runway remaining. (No allowance was made for reverse thrust or decisionmaking time.) In this case, a decision to abort at $V_1$ (2,100 ft remaining) could have resulted in the aircraft's overrunning the end of the runway.

Flight Simulation

A theoretical study of a takeoff from liftoff to a specific altitude is complicated by mony unknowns related to pilot technique. To analyze the accident takeoff, Boeing prepared a flight simulation incorporating the known performance characteristics of the Boeing 727-224 aircraft and the derived wind model. Numerous test flights were flown during which a Boeing test pilot made takeoffs under various representative conditions. The objectives of the simulation study were to identify the most probable control input in the accident takeoff profile and to determine whether the aircraft could have become airborne and cleared the utility poles in the wind condition derived from FDR data.

A simulated takeoff was first conducted under no wind conditions in order to validate the simulation model for the 727-224 aircraft. There was a good correlation between simulated performance and known aircraft performance. Additional simulated takeoffs were conducted using various takeoff techniques. These takeoffs were made with the wind model derived from FDR data affecting aircraft performance.

Several takeoff runs were flown in which the aircraft was initially rotated to a pitch attitude of 11° and, after liftoff, the pitch attitudi was lowered in an attempt to maintain $V_2$. These takeoffs culminated in the aircraft's hitting the utility poles. Recorder traces of these takeoffs approximated the FDR trace of the accident aircraft.

In addition, other takeoffs were flown during which the simulated aircraft missed the utility poles. When the simulator was rotated to 15° and then flown at a pitch attitude of 13" to 15°, the airspeed decreased to about 120 kns and miss-distances of 90 ft were recorded. Takeoffs using the same technique, but with one engine accelerating relatively slowly to target EPR (target EPR reached on all engines by 80 kns), resulted in the same speed decay and miss-distance. Takeoffs with early or slow rotations to 15° followed by pitch attitudes of 13° to 15" after liftoff resulted in airspeed decays to 116 to 120 kns and miss-distances of 90 to 100 ft.

1.17 Other Information

1.17.1 Continental Air Lines, B-727 Takeoff Procedures

Section 4 of Continental's B-727 Flight Manual for flightcrews specified procedures for threa engine takeoffs. Pertinent normal takeoff procedures were specified as follows:

"At $V_R$, rotate the airplane smoothly to the takeoff climbout attitude of approximately 13°. The rate of rotation should be approximately 2° per second. When the airplane is rotated at the proper race. lift-off will normally occur before reaching 10° of body angle, allowing rotation to be continued until climbout attitude is reached.

"Excessive rates of rotation must. be avoided. If the rate of rotation exceeds the proper rate, it is possible to reach an attitude that will cause the tail skid to contact the runway before the airplane can lift off.

"The airplane will normally attain $V_2$ + 10 assuming all engines are operating. approximately 35 feet above the runway."

After takeoff procedures (climb to 1,500 feet) specified:

"1. The airspeed indicator is primary for establishing pitch attitude."

There was nothing in the manual which provided for alteration of the takeoff procedures if variable or gusty surface winds existed or were suspected, or if low altitude turbulence or wind shear existed or was reported to exist.

1.17.2 14 CFR 121.443--Pilot in Command Qualifications: Routes and Airports

With regard to pilot airport qualification, 14 CFR 121.443 states in part:

"(a) No domestic or flag air carrier may use a pilot as pilot in command until he has qualified for the route on which he is to serve, in accordance with this section, and the appropriate instructor or an approved check pilot has so certified.

* * * *

"(c) The qualifyinp pilot shall make an entry as a member of a flightcrew at each regular, provisional, ana refueling airport into which he is scheduled to fly. The entry must include a landing and a takeoff. The qualifying pilot must occupy a sent in the pilot compartment and must be accompanied by a pilot who is qualified for the airport.

"(d) Paragraph (c) of this section does not apply if-

(1) The initial entry is made under VFR weather conditions at the airport involved;

(2) the air carrier shows that the qualification can be made by using approved pictorial means. . . ."

1.17.3 14 CFR 121.447--Pilot Route and Airport Qualifications for Particular Trips

With regard to using a pilot to fly a particular flight 14 CFR 121.447 states in part:

"(a) A domestic or flag air carrier may not use a pilot as pilot in command unless within the preceding 12 calendar months, the pilot has made at least one trip as pilot or other member of a flightcrew between terminals into which he is scheduled to fly. . . ."

1.17.4 Continental Air Lines Boeing 727 Airport Qualification Requirements

The Director of Flight Crew Training, Continental Air Lines stated that the company's airport and route qualifications were essentially the same as those specified in the regulations and he also stated that airport qualifications currency was each captain's responsibility. With regard to recordkeeping, the Continental Operations Manual stated:

"Records of pilot route and airport qualifications are maintained by IBM and are available at the base Flight Manager's offices. When a pilot makes a qualifying trip as ACM, rather than as flight crewmember, he will notify the Flight Manager in writing."

The Safety board was unable to find any records that showed the captain's prior qualification for the Tucson Airport.

A review of Continental's approved slide and tape presentation on the Tucson Airport disclosed no information with regard to use of the displaced threshold area of runway 21 for takeoff, however, the presentation did show the displaced threshold for the runway, specified the length of the displaced area, and showed an approach to the runway.

According to the FAA Principle Operations Inspector assigned to Continental Air Lines, there have been no inspection reports which showed a lack of compliance with the airport qualification requirements. He stated that Continental's Airport Qualification Program was adequate. Additionally, he stated that the company had the responsibility to insure that pilots are qualified in accordance with 14 CFR 121.447(a) but that the company had no procedure that would insure that the dispatcher knew that a pilot was qualified into a given airport before a flight was dispatched.

On January 3. 1975. the Safety Board issued Safety Recommendation A-74-118 to the FAA concerning airport qualifications. and the FAA, in response, issued Air Carrier Operations Alert No. 75-1, which required that "operations inspectors...periodically review their assigned operator's airport and route qualification programs to insure thst all information is up-to-date. that company procedures are consistent with published Federal Aviation Administration procedures and that obsolete procedural material is not included."

1.17.5 Continental Air Lines Wind Shear Training Program

On October 3, 1974, the Safety Hoard issued Safety Recommendations A-76-80 and 81 to the FAA on wind shear training programs for air carrier pilots. The FAA responded on November 19. 1974, that steps had been initiated to emphasize the need for more understanding of the low level wind shear phenomenon and that air carrier Operations inspectors would evaluate each air carrier's wind shear training program. Where they found inadequacies, the inspectors would request modification of the programs to include material on wind shear hazards and on flight techniques needed to counter the effects of wind shear.' As a result of their evaluation, changes were made in the Continental Air Lines training program. Specifically, the slide and tape presentation and simulator training program were added.

The current Continental Air Lines Wind Shear Training Program consists of a slide and tape presentation entitled "Hostile Environment," which has been used in all Recurrent Ground School$ since June 1577; a simulator training program, which provides wind shear training with emphasis on recognition for both landing and takeoff, was begun in January 1976 and is given during all simulator training; and classrocm lectures and discussions on hazardous weather, including wind shear. Included in the program is a comprehensive discussion of wind shear recognition factors associated with thunderstorm and cumulonimbus clouds. The training records of each of the flightcrew memhers showed that they received this training.

In addition to Continental Air Lines' formal wind shear training program, the company published numerous articles on hazardous veather conditions and wind shear in a companv flight operations publication; copies of this publication were made available to each pilot. Recognition factors such as virga and blowing dust were also contained in these articles.

1.17.6 Continental Air Lines Dispatch Procedures

Continental Air Lines Operations Center is located near Los Angeles Airport. From this center, the company provides flight following and operational control. Stations where flights originate are tied into an operations and weather network with the Operations Cenfer. The latest forecasts and weather observations are on hand and made a part of the crew's clearance papers.

The Continental facility at Tucson is not an origination station and the station agent is required to maintain up-to-date weather information which is available from the local Flight Service Station. For intermediate stations, such as Tucson. the Pilot Weight Sheet is computed by the station agent. based on weather. load message information, and the yayload leaving his station. At intermediate stations. if the captain has an aircraft weight clearance problem such as taking off cargo, he may resolve the problem with the station agent, call the operations center from the station agent's desk, or call the operations center via Aeronautical Radio Incorporated and phone patch.

1.17.7 Hazardous Weather Recognition Factors

Gust Fronts From Thunderstorms

Rased on the research on thunderstorms reported in National Oceanic and Atmospheric Administration (NOAA) Technical Memorandum NSSL 61 the following structure of a thunderstorm gust front was developed:

> "A surface wind shift may or may not accompany the gust front, but may lead the gust front hv as much as 3 to 5 miles. The gust front will be marked bv onset of high winds and gustiness at the ground--usually 40 to 50 kns or more. The gust front will move fater than the generating thunderstorms, preceding the nearest edge of the storm by 5 or 10 mi. Vertical wind shears of 10 kn per 100 it in the lower few hundred feet have been measured behind the gust front. Horizontal wind shears of 40 kn have been mensurcd across the gust front. A pressure jump precedes the gust front."

Cumulus Cloud and Vertical h'ind Hazards

Case histories of several recent wind shear encounters indicate that a potential wind shear hazard nay be expected to exist under high based cumulus clouds when the following four conditions are met: (1) High based cumulus type ciouds with virga, (2) very drv surface air with a temperature dewpoint spread of 35° F ot more, (3) weak winds from the ground to the cloud bases--generally lrss than 15 kns, and (4) temperature warmer than 75" F. 27/

27/ United Air Lines Meteorology Department "Hot and Dry Windshear," Aerospace Safety, October 1977, pp. 10 and 11.

## 2. ANALYSIS

General

The aircraft was certificated, equipped, and maintained in accordance with applicable regulations and approved procedures. There was no evidence of a malfunction or failure of the aircraft's structure, flight instruments, or powerplants that would have affected its performance. Although the No. 1 engine was reported slow to spool up when the throttles were advanced at the beginning of the takeoff, it did not affect the aircraft's takeoff performance.

The flightcrew was certificated properly, except for the flight captain who had not been route certified. Each crewmember had received the off-duty time prescribed by regulations. There was no evidence of pre-existing medical problems that might have affected their performance.

The evidence revealed that after his assignment to the flight, the captain had not fulfilled his responsibility to assure that he was familiar with the airports on the route to be flown. He had not made use of a pictorial airport presentation which was available from the air carrier, he had not planned for a qualified pilot to accompany him over his intended route, and he had not made a qualifying entry into the scheduled airports on his route as a member of a flightcrew. Furthermore, a check airman, who had occupied a seat in the pilot compartment to Phoenix and remained In the passenger cabin during the El Paso and Tucson airport entries, did not certify as required by regulation that the captain possessed adequate knowledge of the assigned route. Nevertheless, the Safety Board Concludes that by virtue of his VFR arrival and departure at the Tucson airport, the captain was airport qualified by regulation upon liftoff. However, the Safety Board also concludes that he was not properly certified to operate over the route. If he had been properly route qualified by a check airman or appropriate instructor, the physical layout of the Tucson airport, including the displaced landing threshold should have been brought in his attention.

However, these inadequacies do not lessen the captain's responsibility to have recognized the displaced landing threshold markings on runway 21 which conforms to the standard marking explained in the Airman's Information Manual, Part 1. This part contains "basic fundamentals required to fly in U.S. National Airspace System." Additionally, the Jeppesen airport diagram should have alerted the captain to the presence of the displaced landing threshold.

Following the accident, Continental flight management personnel stated that they considered VFR airport entries only to be adequate to fulfill the regulatory requirements for route qualification. The Safety Board does not believe that this interpretation provides an acceptable level of safety and the Board concludes that the Continental Airlines Airport Qualification Program was not consistent with the intent of the regulations. Further, the evidence indicates that the FAA's surveillance of Continental's airport and route qualification was not in conformity with its own directives.

The Safety Board believes that in addition to the captain's responsibility for insuring proper airport qualifications, the company also has a responsibility. When questioned about their airport qualification program, Continental Air Lines indicated that it is the pilot's responsibility to insure that he meets the qualifications for the routes to be flown. At the time of the accident, the company did not have a monitoring system for insuring that a pilot was properly airport and route qualified before using him as pilot-in-command. The Continental Director of Flightcrew Training stated that in accordance with 14 CFR 121.443 and .447 the company had a responsibility in this regard. however, he indicated that they kept records for the airport qualification film program only. The Board believes that without adequate company record-keeping, it vould be possible to dispatch a pilot as pilot-in-command to airports for which he is not qualified. Presently, as a result of this accident, Continental Air Lines is installing a comprehensive program to monitor route and airport qualifications of flfght captains. All flight operations personnel will have access to the records.

Weather Recognition

The NWS terminal forecast, valid at the time of the accident, was not accurate since a thunderstorm, blowing dust, and gusty winds were not forecast until 1500. However. the Continental Air Lines terminal forecast, which was available to the crew, was substantially correct since it forecast a chance of thunderstorms.

The wind warning in effect at the time of the accident called for strong gusty winds. although neither the Tucson control tower personnel nor the flightcrew received this information. According to the weather observer's testimony, a 26-minute delay in getting the information to the users was caused by the rush of events and other priorities. NWS procedures do not contain a time limit for hazardous weather dissemination. The Board believes that such severe weather information should be disseminated as soon as possible after it is detected if it is to be effective. This warning would have helped alert the flightcrew of a possible wind shear condition. However, the wind report received at 1256:00 indicating a wind from 210' at 30, gusting 50 kns, should have provided the same wind shear alert.

Witness observations. recorded weather data, and the wind model. derived from FDR data support a conclusion that the center of a thunderstorm was slightly north of the airport when Flight 63 took off.

A dust storm originated to the southwest of the airport and proceeded across the airport in a northerly direction. It was accompanied by high surface winds variable in direction with gusts up to 50 kns. The storm was several hundred feet high as it moved rapidly across the airport. Based on these reported characteristics, the Safety Board concludes that this storm was the gust front of a thunderstorm or group of convective clouds which produced strong vertical downdrafts and strong and variable horizontal winds at the surface.

Avoidance of a wind shear encounter depends on timely alerts, and the flightcrew's early recognition of possible wind shear conditions. The Safety Board believes that, in spite of the inaccuracies of the forecast, the captain had other clues that should have alerted him to the possibility of a wind shear encounter: (1) The tower reported gusts up to 50 kns about 2 minutes before the flight's takeoff; (2) the winds shifted rapidly, as much as 90°; and (3) a severe dust storm crossed the approach end of the runway as the flight attempted to take the runway for takeoff.

When the flight left the gate, the captain became aware of blowing dust approaching the airport from the southwest. Discussions recorded on the CVR about 1252 showed the crew's awareness. While taxiing to runway 21, the captain received several reports of high wind speeds and gusts. In fact, gusts up to 50 kns were reported to the flight by the tower controller about 2 minutes before takeoff. The variability of the wind indicated rapid movement or change, which was an additional indication of unstable conditions conducive to wind shear.

These recognition factors should have been a part of the captain's knowledge of thunderstorms and hazardous weather phenomena. The Continental Air Lines wind shear training program was expanded substantially after an accident involving Continental in Denver. 3/ The Safety Board concludes that the company's training program provided sufficient wind shear information to the captain so that his observations regarding the weather at Tucson should have alerted him to the possibilities of wind shear and should have deterred him from taking off under the conditions especially since the wind factor was critical to remain within allowable weight limitations for takeoff on runway 21.

Aircraft Performance

The wind model derived from FDR data showed that the aircraft initially encountered a strong headwind at the start of the takeoff roll. This strong headwind decreased as the aircraft progressed down the runway until relatively calm wind was encountered. This calm was followed by an encounter with a rapidly increasing tailwind. As the

3/ NTSB-AAR-76-14, Continental Air Lines, Inc., B-727, Stapleton International Airport, Denver, Colorado, August 7, 1975.

aircraft lifted off, it encountered a strong crosswind from the right. Based on the recorded and visual evidence, the Board concludes that Flight 63 encountered severe wind shear during the takeoff roll and during a critical phase of the departure.

Continental Air Lines Boeing 727 takeoff procedures call for a smooth rotation to a pitch attitude of approximately 13° and specify that, after takeoff, use of airspeed as the primary reference for establishing pitch attitude. In this accident. the captain rotated the aircraft first to about 11' and tnen increased the pitch attitude when he saw that the aircraft was not climbing. When he saw the airspeed decrease and saw the powerlines, he lowered the pitch attitude before hitting the powerlines.

Aircraft performance analysis and simulation showed that the aircraft could have cleared the utility poles on takeoff if the captain had concentrated on flightpath control rather than airspeed loss in a takeoff situation where airspeed was erratic. The FDR showed that the average rate of climb was 172 ft/min. When the aircraft impacted the utility poles its airspeed was about 128 KIAS. The performance analysis showed that maintaining a 11° pitch attitude after liftoff would result in a rate of climb sufficient to clear a 39-ft ohstacle, although this would have required the pilot to allow his airspeed to decrease to ahout 125 kn.

While the aircraft possessed additional aerodynamic potential to counter the effects of the wind shear, the increased potential existed in a regime oi flight for which the captain had no training or approved operating procedures. Based on the evidence. the Safety Board concludes that tile captain could not have been expected to operate the aircraft other than in accordance with prescribed company procedures.

Because the wind conditions which affected Flight 63 could be derived only from data generated during Flight 63's takeoff, the Safety Board was unable to determine whether the captain's failure to use the full length of runway 21 contribute4 to the accident. A few minutes delay in takeoff because the aircraft had to be taxied to the beginning of the runway may have resulted in the wind conditions that could have been better or worse than those actually experienced. However, even without considering the hazards of windshear, the captain's failure to use all available runwav in a situation where he needed a 3.5-kn headwind component to avoid an overweight takeoff rcduced the intended margin of safety.

The recorded CVR conversations "hang on guys" and "lost all our airspeed" appear to reflect recognition of unusual conditions. However, within about 4 secs the first ofiicer called "V1 rotate." This would have discouraged any thought about rejecting the takeoff at that time even if such a thing was ever entertained.

While :he performance analysis shows that tne aircraft could have been stopped on the runway if the takeoff had been rejected prior to $V_1$, initiation of the takeoff from the displaced threshold rather than from the end of the runway substantially reduced the recognition and decision time, and hence the margin of safety. had any attempt been made to reject the takeoff from that point for any reason.

The problems associated with wind shear have been explored in depth in several Safety Board accident investigation reports. 4/ These accidents involved nircraft on takeoff and'on precision instrument approaches.

The Safety Board is aware of recent wind shear studies conducted by airframe manufacturers. 5/ The studies indicate that aircraft performance in wind shear conditions can be improved by using pitch and airspeed control techniques which differ from the normal procedures specified in most air carrier flight manuals. Because of these recent studies, on February 16, 1978, the Safety Board recommended that the FAA: "Fstablish a joint Government-industry committee to develop flight techniques for coping with inadvertent encounters with severe wind shears at low altitude. (A-73-3;"

4/ NTSB-AAR-74-14, Iberia Lineas Aereas de Espana, DC-10-30, Logan International Airport, Boston, Massachusetts, December 13. 1973
NTSB-AAR-76-8, Eastern Airlines, Inc., B-727, John F. Kennedy International Airport, Jamaica, New York, June 24, 1975.
NTSB-MR-76-14, Continental Air Lints, Inc., B-727, Stapleton International Airport, Denver, Colorado. August 7, 1975.
NTSB-AAR-78-2, Allegheney Airlines, Inc., DC-9. Philadelphia, Pennsylvania, June 23, 1976.

5/ Boeing Company, "Hazards of Landing Approaches and Takeoffs in a Wind Shear Environment," January 1977. C. A Whitmore, R. C. Cokely, Lockheed California Co., "Wind Shears on Final Approach."

# 3. CONCLUSIONS

## 3.1 Findings

1. The aircraft was certificated and maintained according to approved procedures.

2. There was no evidence of a malfunction or failure of the aircraft's structure, flight instruments, or powerplants that would have affected the performance of the aircraft.

3. All crewmembers were properly Certificated, except the flight captain who had not been route certified.

4. Although the captain was technically qualified for the flight, he was not aware of the displaced threshold on runway 21 at the Tucson Airport.

5. The takeoff was initiated from a position on the 7,000-ft runway where 6,500 ft of runway remain (the displaced threshold).

6. With no headwind, the aircraft's weight exceeded the maximum allowable weight for takeoff on runway ?1; a 3.6-kn headwind was needed for takeoff on runway 21 using all available 7.000 Et. A 20-kn headwind was needed for takeoff on runway 21 using 6.500 ft remaining from the displaced threshold.

7. Cumulonimbus clouds with associated rainshowers were slightly north of the airport as Flight 63 began it5 takeoff on runway 21. The bases of the clouds were relatively high and the surface winds were variable, strong, and gusty.

8. Before Flight 63 started its takeoff roll, the captain had clues that should hare alerted hin to the likelihood of a wind shear encounter.

9. The Continental Air Lines wind shear training program was adequate, and it should have provided the captain with the necessary knowledge to recognize the potential wind shear situation.

10. During the first half of the takeoff roll, Flight 63 encountered a strong headwind. The headwind decreased to a calm wind condition and thea to an increasing tailwind at liftoff.

11. Shortly after liftoff at an altitude of less than 35 ft, the aircraft hit two utility poles and several sections of powerlines.

12. When flown according to standard operating procedures, the aircraft could not avoid impact with the powerlices; however, if the aircraft's full aerodynamic capability had been used, the aircraft probably could have cleared the powerlines.

13. The Continental Air Lines Airport Qualification program was not consistent with the intent of the regulations and the FAA's surveillance of their program was inadequate.

### 3.2 Probable Cause

The Natioaal Transportation Safety Board determines that the probable cause of the accident was the captain's decision to take off under evident hazardous wind conditions which resulted in an encounter with severe wind shear and subsequent collision with obstacles in the takeoff path. The rate of climb of the aircraft in these conditions when flown according to prescribed operating procedures was not sufficient to clear the obstacles. However, if the aircraft's full aerodynamic capability had been used, collision with obstacles probably could have been avoided.

## 4. RECOMMENDATIONS

As a result of this accident, the Safety Board has recommended that the Federal Aviation Administration:

"Require that all takeoff analysis data pages of operating gross weights in air carrier manuals are footnoted to identify those runways which contain a displaced threshold. (Class III, Longer-Term Action (A-78-51)

"Require that all operators of certificated airports, where runway designs feature a displaced threshold and taxiways enter the runway at points other than the runway's end, install an easily visible intersection sign which displays a displaced threshold notation. (Class III, Longer-Term Action) (A-78-52)"

BY THE NATIONAL TRANSPORTATION SAFETY BOARD

/s/ JAMES B. KING
Chairman

/s/ FRANCIS H. McADAMS
Member

/s/ ELWOOD T. DRIVER
Member

PHILIP A. HOGUE, Member, filed the following dissent:

August 1, 1978

Philip A. Hogue, Member. Dissenting

Having studied all available information. it is my conclusion that the probable cause of subject accident should be stated as follows:

"The National Transportaticn Safety Board determines that the probable cause of the accident was the pilot's failure to utilize the full 7.000 feet of runway available versus the 6,500 feet he did utilize."

In arriving at my conclusion, I do not concur that "The probable cause of the accident was the captain's decision to take off under evident hazardous wind conditions (underlining supplied) which resulted in an encounter with severe wind shear and subsequent collision with obstacles in the takeoff path. The rate of climb of the aircraft in these condition,: when flown according to prescribed operating procedures was not sufficient to clear the obstacles. However, if the aircraft's full aerodynamic capability had been used, collision with obstacles probably could have been avoided."

There is no conclusive evidence that the captain's wind shear training was sufficient to enable him to recognize or suspect wind shear under the specific conditions of this accident. In fact, it is not clear that understanding of and criteria for wind shear exists today to do this. It is not clear that specific criteria regarding takeoffs and landings in hazardous weather exists. How long should the captain have waited until he took off? He waited until the dust storm passed. Was his action inadequate, and if so, by what criteria? In support of my view, I note the National Weather Service does not warn specifically of wind shear in its weather observations. If the weather experts and current technology cannot provide positive wind shear information, it is not logical to expect pilots to ordinarily or routinely make wind shear decisions independently.

I concur that wind shear was prohably a factor in this accident, but from the pilot's position he had clear visibility, the dust storm had passed, he had at least 13 knots of headwind "predominantly out of the southwest" and within his knowledge and experience. there was no valid reason to fail to take off. Insofar as his subsequent encounter with wind shear was concerned, it was inadvertent.

/s/ PHILIP ALLISON HOGUE
Member

# 5. APPENDIXES

## APPENDIX A

## INVESTIGATION AND HEARING

### 1. Investigation

The Safety Board was notified of the accident on June 3, 1977. An investigator-in-charge was dispatched froe the Los Angeles Field Office. Working groups were established for the on-scene investigation, the flight data recorder, and the cockpit voice recorder.

Participants in the on-scene investigation included representatives of the Federal Aviation Administration, Continental Air Sines, Inc., and the Air Line Pilots Association.

### 2. Public Hearing

Although there was no public hearing, deposition proceedings were held August 25 and 26, 1977. Parties represented at the deposition proceedings were: The Federal Aviation Administration, Continental Air Lines, Inc.. The Air Line Pilots Association, The National Weather Service, The Boeing Company, and The Professional Air Traffic Controllers Organization.

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# APPENDIX B

## CREW INFORMATION

Captain Thomas E. Gullctt

Captain Gullett, 41, holds Airline Transport Pilot Certificate No. 1374588 with type rating in B-727, DC-6, and DC-7 aircraft. He has commercial privileges with airplane single-engine an? multiengine land ratings. He held a first-class medical certificate with no limitations which was issued April 25. 1977.

Captain Gullctt satisfactorily passed his last proficiency check on March 15, 1977. when he was also requalified as a B-727 captain. His last line check was June 3, 1977. When the accident occurred. check captain was seated in the passenger cabin. At the time of the accident, he had 6,820 flight-hours, 320 of which were as pilot-in-command of B-727 aircraft and 100 of which were as first officer of B-727 aircraft. He had flown 98:09 hours during the 90 days preceding the accident.

First Officer John H. Garrett

First Officer Garrett, 37, holds Commercial Pilot Certificate No. 1556710 with airplane single-engine land. multiengine land, rocorcraft. and instrument ratings. He held a first-class medical certificate with no limitations which was issued on August 18, 1976.

First Officer Garrett satisfactorily passed his last proficiency check on March 10, 1977. At the time of the accident. he had 5,500 flight-hours, 1,721 of which were in the B-727 aircraft. He had flown 129 hours during the 90 days preceding the accident.

Second Officer Harry T. Pearce

Second Officer Pearce, 38, holds Flight Engineer Certificate No. 1922371 with a turbojet power rating. He held a first-class medical certificate which was issued with no limitation on January 19, 1977.

At the time of the accident, Second Officer Pearce had 5,053 hours as n second officer, all of which was in B-727 aircraft. He had flown 205 hours during the 90 days preceding the accident.

Flight Attendants

The four flight attendants were qualified in the B-727 in accordance with applicable regulations and received the required emergency evacuation training.

APPENDIX C

AIRCRAFT INFORMATION

N32725 was manufactured by The Boeing Company on April 10, 1973. and assigned serial No. 20655. It had accumulated a total of 12,793:40 hours in service.

N32725 was powered by three JT8D-9A turbofan engines. Pertinent engine data are as follows:

| Position | Serial No. | Total Time | Total Cycles | Total Time Since Last Service Check |
|---|---|---|---|---|
| 1 | P665527BA | 19,949:03 | 18,487 | 459:52 |
| 2 | P665605BA | 14,905:54 | 14,341 | 459:52 |
| 3 | P665298BA | 22,388:48 | 20,085 | 1,091:54 |

## CALCULATED
## TAKEOFF WEIGHT AND WIND REQUIREMENTS

| | Calculations Based On Station Agent's Weight Data Runway 21 | |
|---|---|---|
| **Gross Weight** | | |
| Estimated Wgt Ready for Flight (includes crew, water, catering, oil, etc.) | 100,300 LB | |
| Fuel On Board (includes Agent's 700 Lb Revision) | 18.900 | |
| Fuel Required for Start and Taxi | - | |
| Payload (165 Lb/Passenger) | 14,355 | |
| Cargo | 4,182 | |
| 2 Additional Crew Members | 220 | |
| Total Used to Calculate Wind Required | 137,960 LB | |
| **Wind Required** 7,000 Ft Runway | | |
| Max Wgt for T/O - No Wind 95°F | 137,000 LB | |
| Actual Overweight - Zero Wind | 960 LB | Overgross no wind |
| Headwind Required (1KT/270 Lbs.) | 3.6 KNS | |
| **Wind Required** 6,509 Ft Runway | | |
| Max Wgt for T/O - No Wind/95°F | 132.749 LB | |
| Actual Over weight - Zero Wind | 5,481 Lb | Overgross no wind |
| Headwind Required (1KT/270 Lbs.) | 20 KNS | |

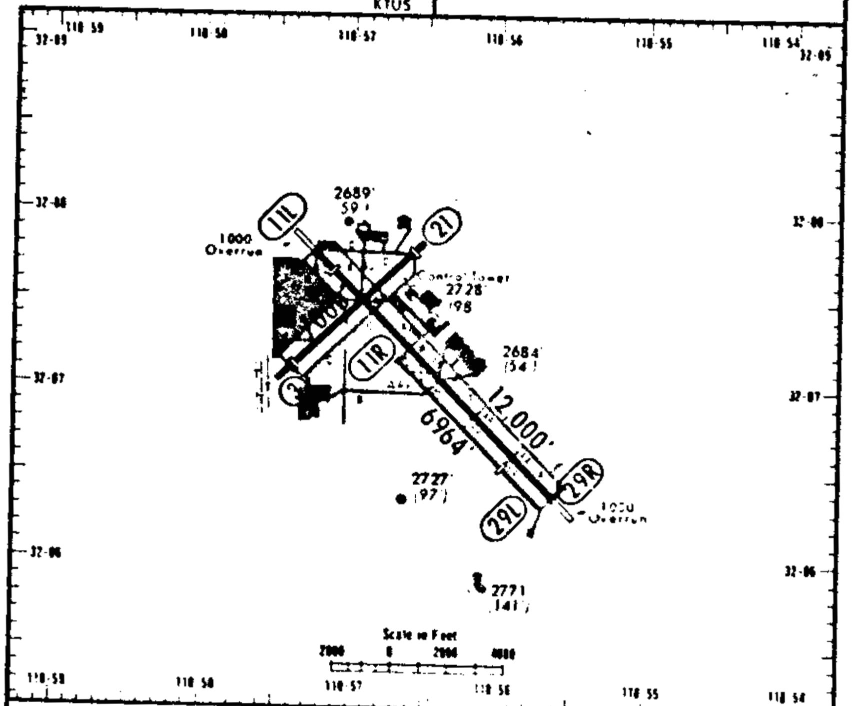
## APPENDIX E

**TUCSON, ARIZ.**
**TUCSON INT'L APT.**
Elev 2630' N32 07.1 W110 56.5

(11-1) OCT 17 75 Jeppesen Approach Chart

NOTE: Airport of entry.

KTUS




ADDITIONAL RUNWAY INFORMATION

| RWY | LIGHTING | USEABLE LENGTHS LANDING BEYOND Threshold | Glide Slope | TAKE OFF | WIDTH |
|---|---|---|---|---|---|
| 3 / 21 | MIRL | 6149' | | | 150' |
| 11R / 29L | | 6500' | | | 75' |
| | | 5202' | | | |
| 11L / 29R | HIRL / HIRL VASI 3 bar | 10 900' | 9900 | | 150' |

AIR CARRIER TAKE-OFF

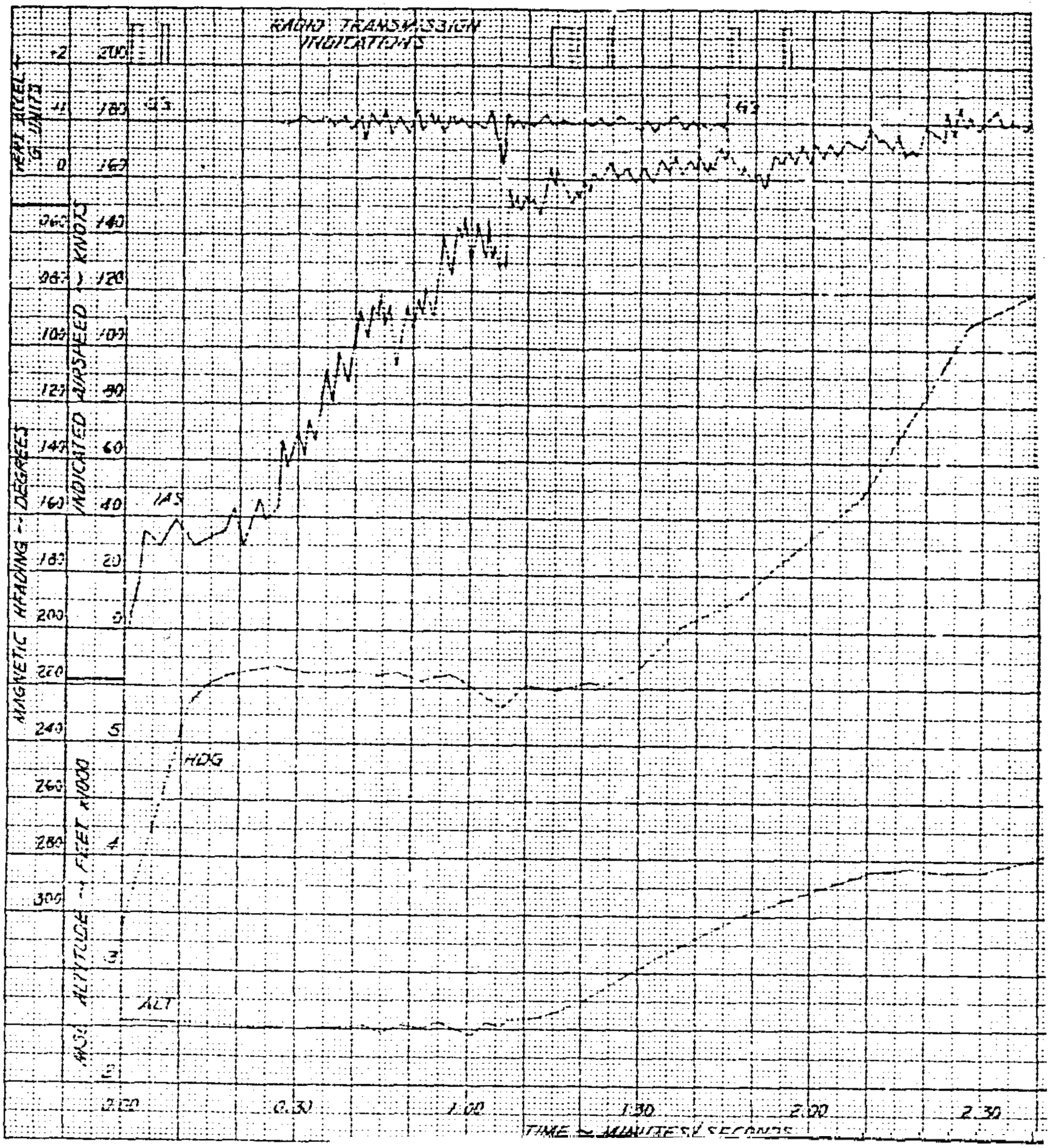
| | SCHEDULED | | Air Agencies & Air Carriers | | ALTERNATE CEILING VISIBILITY ILS Approach | Other Approach |
|---|---|---|---|---|---|---|
| | ½ | 1 | 1 | Landing Weather Minima | 600-2 | 800 2 |
| | ¼ | | | | 700 2 | |
| | | ¼ | | | | |

500 ceiling required rwy 21.
IFR departure procedure: Rwy 3 turn left heading 320 rwys 11L R, 21 & 29L R turn right heading 350 intercept TUS VOR R 303 to Cortaro Int then via assigned route, minimum 5000.

Part 135 Operators 3 4 authorized rwy 11L.
VOR A VOR DME B & NOB C approaches 1200 2.

CHANGES VASI rwy 29R.

35/36

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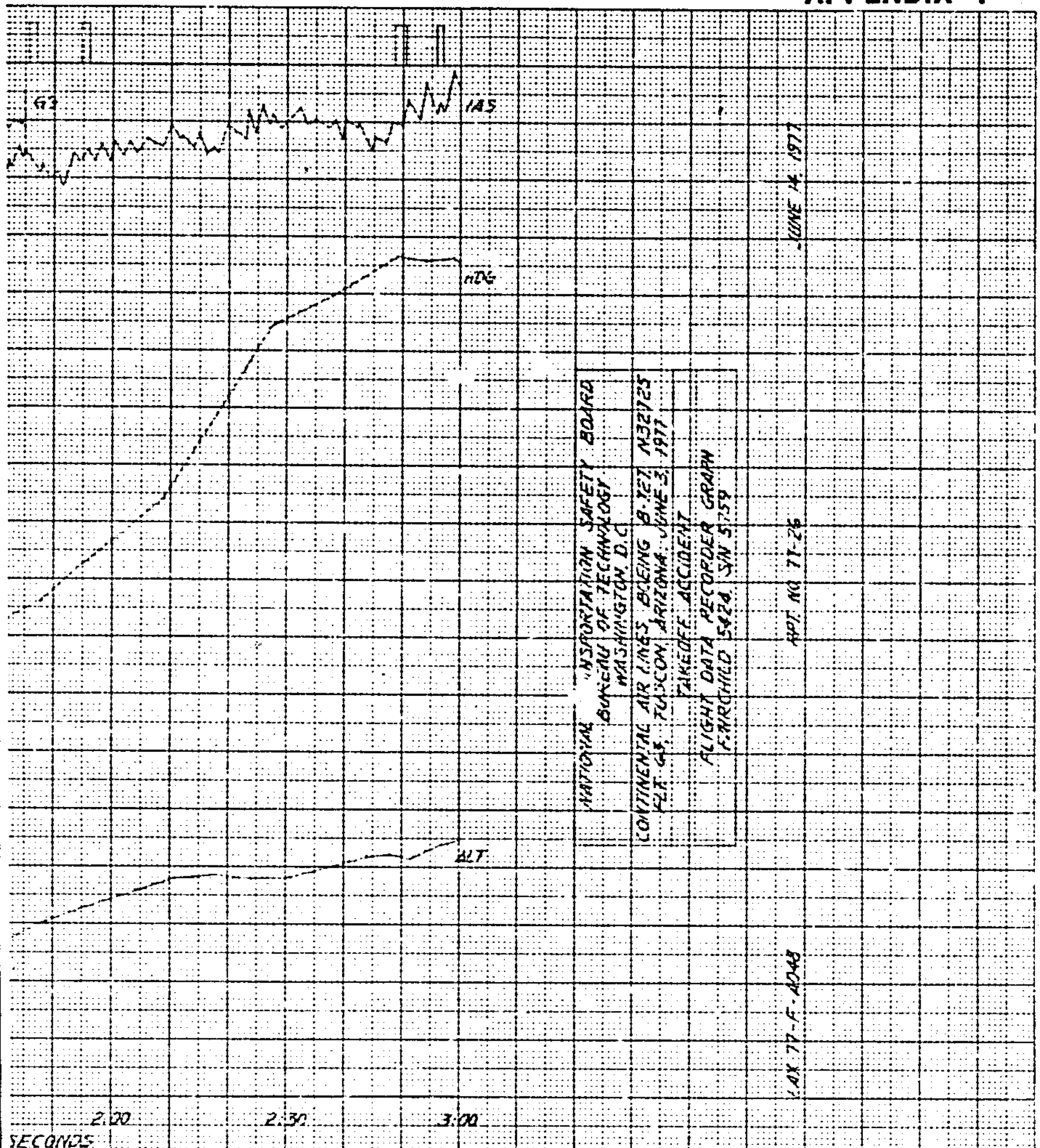
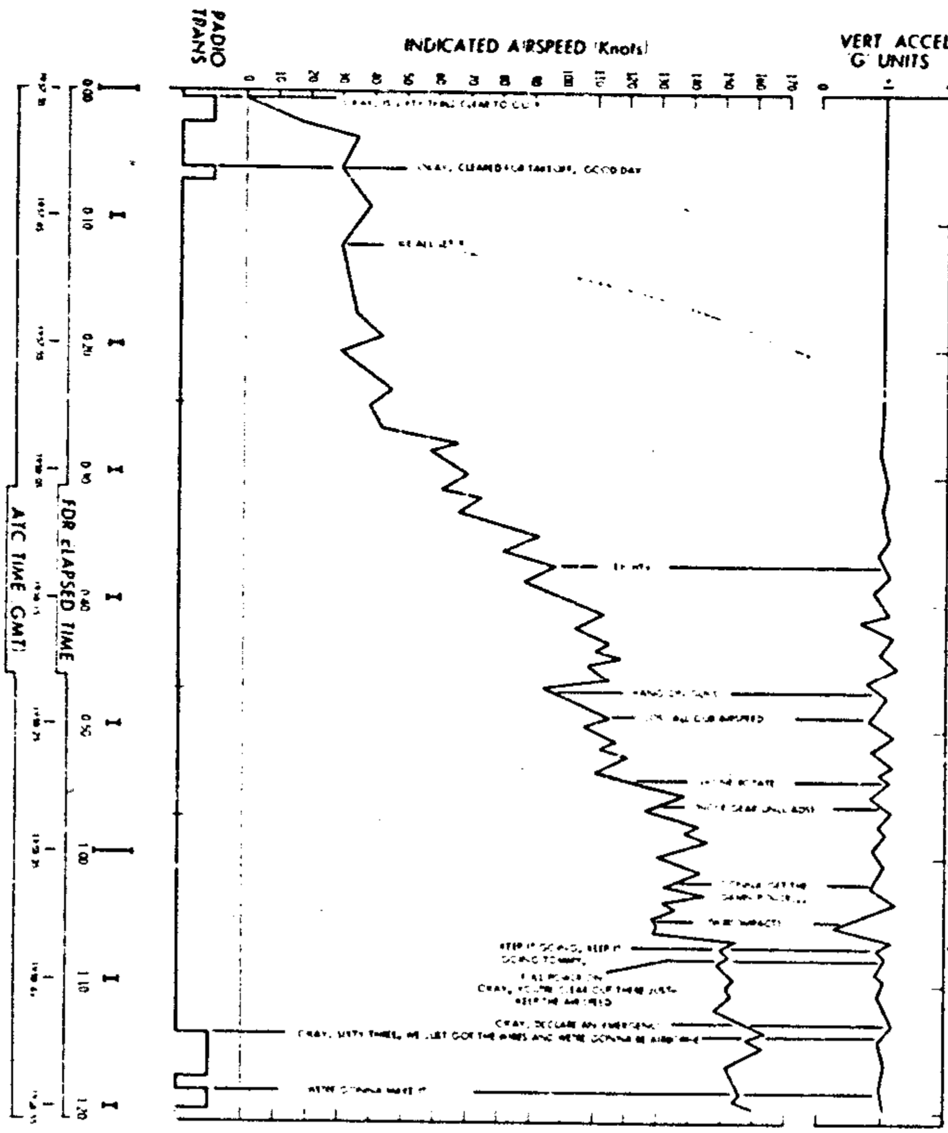
# APPENDIX F



G3
IAS
HDG
ALT
NATIONAL TRANSPORTATION SAFETY BOARD
BUREAU OF TECHNOLOGY
WASHINGTON, D.C.
CONTINENTAL AIR LINES BOEING B-727, N32725
FLT. 63, TUSCON, ARIZONA JUNE 3, 1977
TAKEOFF ACCIDENT
FLIGHT DATA RECORDER GRAPH
FAIRCHILD 5424, S/N 5759
RPT. NO 77-26
JUNE 14, 1977
LAX 77-F-A048
2:20
2:30
3:00
SECONDS

APPENDIX F




Continental Airlines, Boeing B-727, N32725 Flt. 63, Tucson, Arizona, June 3, 1977

**727**
FLIGHT MANUAL

CONTINENTAL AIRLINES

SEC. 4B PAGE TUS-3
REV. 12-1-73

# 15° FLAPS

ELEVATION: [illegible]

## TUCSON, ARIZ.

Tucson Int'l. (TUS)

B727-224

| AMBIENT TEMP (°F) | (ZERO WIND) RUNWAY LIMIT WEIGHT (100 LBS) 3 | 11L | 21 | 29R | | | STRUCT 2nd SEGMENT | AMBIENT TEMP (°F) |
|---|---|---|---|---|---|---|---|---|
| -10 | 1655 | 1930 | 1645 | [illegible] | | | 1690 | -10 |
| 0 | 1638 | 1930 | 1629 | [illegible] | | | 1690 | 0 |
| 10 | 1621 | 1930 | 1612 | [illegible] | | | 1690 | 10 |
| 20 | 1605 | 1930 | 1597 | [illegible] | | | 1690 | 20 |
| 30 | 1568 | 1930 | 1560 | 1900 | | | 1690 | 30 |
| 32 | 1561 | 1923 | 1553 | [illegible] | | | 1690 | 32 |
| 34 | 1554 | 1916 | 1546 | 1900 | | | [illegible] | 34 |
| 36 | 1546 | 1909 | 1539 | [illegible] | | | 1690 | 36 |
| 38 | 1539 | 1902 | 1531 | [illegible] | | | 1690 | 38 |
| 40 | 1532 | 1695 | 1524 | [illegible] | | | 1690 | 40 |
| 42 | 1524 | 1687 | 1516 | [illegible] | | | 1690 | 42 |
| 44 | 1516 | 1680 | 1509 | [illegible] | | | 1690 | 44 |
| 46 | 1509 | 1873 | 1501 | [illegible] | | | 1690 | 46 |
| 48 | 1501 | 1866 | 1493 | [illegible] | | | 1690 | 48 |
| 50 | 1493 | 1859 | 1466 | [illegible] | | | 1690 | 50 |
| 52 | 1485 | 1849 | 1477 | 1876 | | | 1690 | 52 |
| 54 | 1476 | 1840 | 1469 | [illegible] | | | 1690 | 54 |
| 56 | 1468 | [illegible] | 1461 | [illegible] | | | 1690 | 56 |
| 58 | 1460 | 1821 | 1452 | [illegible] | | | 1690 | 58 |
| 60 | 1455 | 1816 | 1447 | [illegible] | | | 1690 | 60 |
| 62 | 1453 | 1813 | 1446 | [illegible] | | | 1690 | 62 |
| 64 | 1451 | 1811 | 1444 | [illegible] | | | 1690 | 64 |
| 66 | 1449 | 1809 | 1442 | [illegible] | | | 1690 | 66 |
| 68 | 1447 | 1807 | 1443 | [illegible] | | | 1690 | 68 |
| 70 | 1445 | 1805 | 1438 | 1831 | | | 1690 | 70 |
| 72 | 1443 | 1803 | 1436 | [illegible] | | | 1690 | 72 |
| 74 | 1441 | 1800 | 1434 | [illegible] | | | 1690 | 74 |
| 76 | 1439 | 1798 | 1432 | [illegible] | | | 1690 | 76 |
| 78 | 1436 | 1795 | 1430 | [illegible] | | | 1690 | 78 |
| 80 | 1434 | 1791 | 1428 | [illegible] | | | 1690 | 80 |
| 82 | 1431 | 1790 | 1425 | 1815 | | | 1690 | 82 |
| 84 | 1429 | 1787 | 1423 | [illegible] | | | 1690 | 84 |
| 86 | 1419 | 1774 | 1413 | [illegible] | | | 1690 | 86 |
| 88 | 1410 | 1761 | 1403 | [illegible] | | | 1690 | 88 |
| 90 | 1400 | 1748 | 1394 | [illegible] | | | 1690 | 90 |
| 92 | 1390 | 1735 | 1384 | 1774 | | | [illegible] | 92 |
| 94 | 1381 | 1723 | 1375 | [illegible] | | | 1665 | 94 |
| 96 | 1371 | 1710 | 1365 | 1757 | | | 1654 | 96 |
| 98 | 1362 | 1698 | 1355 | [illegible] | | | 1639 | 98 |
| 100 | 1352 | 1685 | 1346 | [illegible] | | | 1624 | 100 |
| 110 | 1306 | 1625 | 1298 | 1676 | | | [illegible] | 110 |
| 119 | 1260 | 1565 | 1253 | 1616 | | | 1473 | 119 |
| LENGTH (FT) | 7300 | 12000 | 7300 | 12000 | | | | |
| SLOPE (%) | 0.13UP | 0.63UP | 0.13DN | 0.63DN | | | | |
| NORMAL LIMITATION | RWL | B.E. | OBS | B.E. | | | | |
| HEADWIND ADD LB/KT | 290 | 120 | 270 | 150 | | | | |
| TAILWIND SUB LB/KT | 1190 | 1230 | 1180 | 1230 | | | | |

IMPORTANT NOTES

**LIMITATIONS**

RUNWAY LENGTH.........:RWL
OBSTACLE...............:OBS
BRAKE ENERGY..........:B.E.
NOISE ....................:N.L.
Structure or Second Segment..........:SSS

FLAPS **FIFTEEN**

D9

TUS

OPS.ENG.REF 6

Continental Air Lines, Procedures for Use of Takeoff Weight Charts
Maximum Take-Off Weight

The Maximum Take-Off Weight limitation for the particular combination of airport, flap setting, temperature, runway and winds, is the LESSER of the weights determined in Steps A and B below. The WAT (weight, altitude, temperature) (Struct/2nd segment) limit (Step A) and the Runway Limit (Step B) are calculated separately because they are two distinctly different limitations (but neither one may be exceeded).

If the runway selected does not permit sufficient take-off weight, consider the possibility of using a different runway. This will involve repeating Step B for the new choice of runway (including revision of wind component if the runway direction is different).

If more than one take-off flap setting is available for the particular airplane type, then it may be beneficial to choose another flap setting. In general, the smaller flap settings result in the highest WAT (Struct/2nd segment) limit weights, but at the same time longer runway lengths are required.

A. WAT (Struct/2nd Segment) Limit - the WAT (Struct/2nd Segment) Limit is the maximum allowable take-off weight for the altitude (of the airport) and the temperature (at the time of take-off). Determine the WAT (Struct/2nd Segment) Limit weight be entering the airport charts with the airport ambient temperature (in degrees Fahrenheit). Follow the temperature line to its intersection with the (heavy) line labelled "WAT" or column labelled Struct/2nd Seg. Read horizontally and record the WAT (Struct/2nd Segment) limited weight.

NOTE: The WAT (Struct/2nd Segment) Limit is independent of runway length and the actual take-off weight MUST NEVER EXCEED this limitation no matter how long a runway is available.

B. Runway Limit - The next weight to be determined is the maximum take-off weight for the particular runway to be used; including limitations due to obstructions beyond the runway, wheel brake energy limitations, tire speed limitations, etc.

Again, enter the airport chart with the (ambient) airport temperature. Proceed along the temperature line to its intersection with the line or column identified by the number of the runway to be used. Read horizontally an3 record the (zero wind) runway limited weight. This weight must now be corrected foi winds (if any) as follows:

Determine the wind component parallel to the runway (from the reported wind by using the "Wing Component" chart in this section).

(1) For a Headwind

(a) MULTIPLY the headwind component by the "LB/knot to add" shown on the chart. This product is the headwind correction.

(b) ADD the headwind correction to the (zero wind) runway limited weight obtained above. The result is the RUNWAY LIMITED WEIGHT.

(2) For a Tailwind

(a) MULTIPLY the tailwind component by the "LB/knot to subtract" shown on the chart. This product is the tailwind correction.

(b) SUBTRACT the tailwind correction from the (zero wind) runway limited weight obtained above. The result is the RUNWAY LIMITED WEIGHT. (Take-off is NOT AUTHORIZED if the tailwind exceeds 10 knots.)