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16. Abstract At 1525 c.d.t., August 6, 1976, N9446Z crashed while attempting an emergency landing on runway 4L at Midway Airport, Chicago, Illinois. The left engine failed during climbout from Midway Airport, which precipitated an uncontrollable engine fire. The aircraft crashed into a residential area about 3/4 mile west of the airport. The aircraft was destroyed, and its two crewmembers killed. One person on the ground was killed, and one person was injured seriously. Two houses, two garages, three automobiles, and a boat were destroyed. The National Transportation Safety Board determines that the probable cause of the accident was the deterioration of the cockpit environment, due to smoke to the extent that the crew could not function effectively in controlling the aircraft under emergency conditions. The smoke and fire, originating from a massive failure in the power section of the left engine, propagated into the bomb bay area and then into the cockpit. The inspection system utilized was not effective in detecting the impending engine failure.					
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NATIONAL TRANSPORTATION SAFETY BOARD
WASHINGTON, D.C. 20594

AIRCRAFT ACCIDENT REPORT

Adopted: April 14, 1977

AIR CHICAGO FREIGHT AIRLINES, INC.
NORTH AMERICAN TB-25N, N9446Z,
MIDWAY AIRPORT, CHICAGO, ILLINOIS,
AUGUST 6, 1976

SYNOPSIS

At 1525 c.d.t., August 6, 1976, N9446Z crashed while attempting an emergency landing on runway 4L at Midway Airport, Chicago, Illinois. The left engine failed during climbout from Midway Airport, which precipitated an uncontrollable engine fire. The aircraft crashed into a residential area about 3/4 mile west of the airport.

The aircraft was destroyed, and its two crewmembers killed. One person on the ground was killed, and one person was injured seriously. Two houses, two garages, three automobiles, and a boat were destroyed.

The National Transportation Safety Board determines that the probable cause of the accident was the deterioration of the cockpit environment, due to smoke to the extent that the crew could not function effectively in controlling the aircraft under emergency conditions. The smoke and fire, originating from a massive failure in the power section of the left engine, propagated into the bomb bay area and then into the cockpit. The inspection system utilized was not effective in detecting the impending engine failure.

1. FACTUAL INFORMATION

1.1 History of the Flight

At 1520:48 ^{1/} on August 6, 1976, a North American T8-25N, an aircraft owned by War Aero, Inc., was cleared for takeoff on runway 4L at Midway Airport, Chicago, Illinois. The flight was cleared to turn left and proceed southwest after departure. The flight was conducted to prepare the copilot for his B-25 type-rating examination.

After takeoff, the aircraft turned southwest and climbed to an estimated altitude of 2,000 feet to 2,500 feet. ^{2/} At 1525:12, the pilot of N9446Z advised Midway tower, "Emergency, request straight in 4462." This was the last radio transmission from N9446Z. Midway Tower responded, "Cleared straight in four left." At 1525:46, a P-51 in the landing pattern at Midway advised the tower that N9446Z had crashed.

Ground witnesses reported that the engine runup before takeoff appeared normal; however, during the takeoff roll, light-colored smoke was seen coming from the left engine. During climbout and after the aircraft had turned southwest, the intensity of the smoke increased then changed to a heavy black smoke, followed by flames. The aircraft then turned left to an easterly heading toward the airport. Witnesses reported that the propeller of the left engine was feathered at this time. A 45" turn to the left was followed by a right turn back to an easterly heading.

Smoke from the left engine ceased briefly at this point, but reappeared shortly thereafter. The aircraft then began a shallow descent, and the left engine again began to emit heavy black smoke.

Witnesses watched flames and smoke engulf the left engine and the forward section of the bomb bay compartment. At this time, the aircraft was observed in a shallow descent at an altitude estimated to be 500 feet to 800 feet above the ground.

Numerous witnesses observed an occupant of the aircraft (later identified as the instructor pilot) protruding from his waist up, out of the copilot's right side window. The occupant was described as waving his arms back and forth. Witnesses also stated they saw a man's arm waving from out of the aircraft's left side window.

Witnesses reported that the aircraft pitched up suddenly as it reached tree-top level. Simultaneously, the landing gear was extended, and the aircraft pitched abruptly downward on a 45° angle. The aircraft crashed into a residential area, located .78 miles west of the approach end of runway 4L.

^{1/} All times herein are central daylight, based on the 24-hour clock.

^{2/} All altitudes herein are mean sea level unless otherwise indicated.

- 3 -

The accident occurred during daylight hours. Geographic coordinates of the accident were latitude 40° 46' 45.9" N and longitude 87° 46' 43" W.

1.2 Injuries to Persons

<u>Injuries</u>	<u>Crew</u>	<u>Passengers</u>	<u>Others</u>
Fatal	2	0	1
Serious	0	0	1
Minor/None	0	0	

1.3 Damage to Aircraft

The aircraft was destroyed.

1.4 Other Damage

Two houses, two garages, three automobiles, and a boat were destroyed. A house was damaged substantially, and nine others were damaged slightly.

1.5 Personnel Information

The two crewmembers were properly certificated for the flight. (See Appendix B.)

1.6 Aircraft Information

The aircraft was certificated as a limited category aircraft and maintained according to Federal Aviation Administration (FAA) requirements. (See Appendix C.)

At takeoff, the aircraft's gross weight was 23,409 pounds, including 4,200 pounds of 100/130 octane aviation fuel. The center of gravity (c.g.) was placed at 239.26 inches. The weight and c.g. for the flight were within prescribed limits at the time of the accident.

The aircraft was purchased by Air Chicago Freight Airlines, Inc., on July 18, 1974, and flown to Midway Airport for major alterations and refurbishing. Registration of the aircraft was then transferred to War Aero, Ltd., a company created by Air Chicago Freight Airlines, Inc., to separate ownership of the B-25 from their 14 CFR 135.2 operation.

The first page of the aircraft logbook contained the entry "Aircraft Log Burn (sic) up in home fire. Est. time airframe 2,500 total time." Other entries included a signed annual inspection, dated December 30, 1972.

Pages in the aircraft logbook failed to identify the aircraft and its engines. Logbooks listed the engines as Wright 2,600's without serial numbers. The initial entry, dated 1972, under No. 1, states, "Time taken from Air Force Logs--Total time since MOH 175.00." A similar entry for No. 2 lists 185.00 hours. There were no copies of logbook pages made after these dates.

Aircraft records provided by the previous owner did not contain information concerning engine preservation, engine preoiling, runups, or oil changes. The aircraft remained inactive following its purchase by Air Chicago Freight Airlines, Inc. From July 1974 to February 1976, the engines were neither preserved nor run up. Furthermore, the engines were not preoiled as recommended by the manufacturer before they were started in February.

In August 1976, compression checks on the engines disclosed low compression on some cylinders on both engines. As a result, the Nos. 1, 2, 3, and 4 cylinders were changed in the left engine and the No. 14 cylinder was changed in the right engine.

In February 1976, maintenance on N9446Z was increased. Maintenance included a complete inspection in accordance with 14 CFR 91.217, as authorized by the FAA General Aviation District Office No. 3 at St. Charles, Illinois. Records indicate that, before the accident, the inspection was completed and there were no uncorrected discrepancies.

A 30-minute test flight, flown the day before the accident, was the aircraft's first flight in 2 years. Before the test flight, high speed taxi runs were made. To correct a nose-wheel shimmy, the nose wheel and tire were replaced and the shimmy dampner adjusted and serviced. Additionally, the control arms for the superchargers were adjusted on both engines to correct low manifold pressures.

Upon completion of the test flight, the following discrepancies were reported: The ADF would not lock on, the DME was inoperative, and the oil pressures on both engines were lower than desired. Although the oil pressures for the left and right engines were within the specified limits, the pilot requested that they be increased 10 psi and 15 psi, respectively. Consequently, the maintenance crew adjusted the oil pressure relief valves on both engines to 80 psi during an engine runup. The relief valves were then secured, and the engines were washed and checked for oil leaks.

1.7 Meteorological Information

Surface weather observations at the Midway Airport were made by FAA tower personnel who were certificated by the National Weather Service (NWS).

Weather observations for Midway Airport, for August 6, 1976, at the times indicated were as follows:

1451 - Ceiling--measured 3,400 feet broken, **8,000** feet overcast, visibility--15 miles, wind--040" at 14 kn, temperature--70° F, dewpoint--54° F, altimeter setting--30.01 in.

1536 - Ceiling--measured 3,500 feet broken, **8,000** feet overcast, visibility--15 miles. wind--030° at 15 kn, altimeter setting--30.10 in. Breaks in overcast.

1.8 Aids to Navigation

Not applicable.

1.9 Communications

No air-to-ground communication difficulties were reported.

1.10 Aerodrome Information

Midway Airport is equipped with a fully operational control tower. Runway 4L is 175 feet wide and 5,509 feet long, and has a macadam surface. The surface was clear and dry at the time of the accident.

1.11 Flight Recorders

No flight data recorder or cockpit voice recorder was installed in the aircraft, nor was either required.

1.12 Wreckage and Impact Information

The crash site was located in a residential area about 3/4 mile west of the airport. The wreckage came to rest on a magnetic heading of approximately 090° and was confined to an area between South Merrimac Avenue and an alley east of South Moody Avenue. Pieces of the fuselage were scattered along the entire wreckage path; the main section of the aircraft came to rest in the basement of a house about 400 feet from the point of initial impact.

The impact forces caused nearly complete fragmentation of the cockpit. Small sections of the instrument panel, glare shield, and the overhead portion of the cockpit were found clear of the main wreckage. These sections had not been damaged by either ground or in-flight fire. Sections of the bomb bay doors had been distorted by intense heat.

The right engine had separated from the wing structure and was severely damaged by impact and ground fire. A front-row cylinder head was torn away and the rear accessory case was destroyed by fire. Blade angles of the right propeller, as indicated by the shim plate fractures and markings, were 34° for the Nos. 2 and 3 propeller blades. The shim plate for the No. 1 blade was unreadable because of impact damage. Nos. 1 and 3 propeller blades were bent rearward about 30° and the tip sections of all three blades were broken off. Nos. 1 and 2 propeller blades exhibited rotational scratches. Examination of the right engine's spark plugs disclosed no indication of combustion-chamber distress. The oil sump, oil screen, and magnetic sump plugs of the right engine were free of contaminants.

The left engine had separated from the wing structure and was damaged severely by impact and ground fire. The front portion of the nose case was shattered, exposing the front end of the crankshaft.

Examination of the left engine disclosed a massive internal failure. A large accumulation of metal fragments was found in the oil screen and sump. Some fragments were identified as parts of piston rings, piston material, and generally a combination of both ferrous and nonferrous metal.

The No. 1 cylinder, which houses the master rod for the rear row of cylinders, contained a 6- by 6-inch hole in the right side of the cylinder barrel. The No. 1 master rod separated about 5 inches below the centerline of the piston's pin bushing location. The lower end of the master rod remained attached to the crankshaft. Fractured surfaces were so mutilated that the origins of the fractures could not be determined. Fragments of the No. 1 piston assembly and two pieces of the master rod were found in the crankcase.

The rear row of articulated rods was broken; rear-row intake and exhaust pipes were generally fractured and bent. Examination of the front row of cylinders disclosed no evidence of mechanical distress. Shim plate fractures and impact marks confirmed that the left propeller was feathered at impact.

Soot and streaks of oil, which conformed to in-flight airflow patterns, were evident on the horizontal and vertical stabilizers. There was no evidence that the primary structure or any of the flight control systems failed in flight.

Fire bottles for the left and right engines were recovered undamaged. The fire bottle for the left engine had been electrically discharged and was empty; the fire bottle for the right engine was full and its squib was still intact.

The landing gear was found extended and the flaps were in an intermediate position. The position of the landing gear or flap handle could not be determined.

1.13 Medical and Pathological Information

The two crewmembers sustained fatal injuries. Post-mortem examination disclosed that the pilot had sustained third-degree burns on his hands, feet, and legs. **No** evidence of fire-related injury was found on the copilot. However, analysis of his blood disclosed a carbon monoxide level of 20 percent. Neither crewmember showed evidence of searing of the trachea **or** lungs. At impact, both crewmembers were thrown clear of the wreckage.

Toxicological studies performed on both pilots showed no evidence of alcohol, barbiturates, tranquilizers, **or** narcotics. **No** evidence of preexisting or incapacitating diseases was found.

1.14 Fire

A ground fire erupted when the left wing separated from the fuselage at impact and spilled fuel was ignited by the left engine. As the ground fire spread, one house caught fire and was destroyed. The local fire department was notified immediately and firetrucks were at the crash site within 5 minutes. The fire was confined to the crash site.

1.15 Survival Aspects

✓ **This** accident was not survivable. The aircraft was not equipped with either oxygen masks **or** smoke goggles, nor was it required to be.

1.16 Tests and Research

1.16.1 Oil Analysis

The National Transportation Safety Board retained an independent chemical laboratory to analyze oil samples from both engines. Results disclosed that the **oil** systems of both engines contained high concentrations of wear metals, corrosion products, and metal particles. (See Appendix **D.**)

1.16.2 Performance Data

The Safety Board examined the single-engine climb charts contained in Army Technical Order **1B-25(T)N-1**. It determined that, at a gross weight of 24,000 pounds, N94463 was capable of a 600 feet per minute climb rate with one engine inoperative and **its** propeller feathered. This rate was calculated based on the prevailing atmospheric conditions at the time of the accident.

In Section 111, page 55, the Technical Order states,

"The single-engine flight characteristics of the airplane are excellent. The airplane can be flown and landed safely on one engine if the pilot understands single-engine flight principle and fully masters the single-engine procedures."

Section 111, page 68: Emergency Procedures

"Engine Fire During Flight

1. Feather propeller for engine on fire.
2. Mixture control lever for engine on fire - IDLE CUT-OFF.
3. Fuel shut off valve handle for engine on fire - OFF (pull).
4. After propeller stops rotating - turn fire extinguisher switch to ON.
5. Cowl flaps - 1/4 open.
6. Ignition switch - OFF.
7. Shut down engine completely.
8. After fire is extinguished and the engine has cooled sufficiently, the cowl flaps may be closed to obtain minimum drag."

"WARNING

"Do not restart engine. Land as soon as possible and investigate cause of fire.

"When fire in engine occurs in flight, **do** not open pilot's escape hatch, forward entrance hatch, (except for bail out) or pilot's side windows since doing **so** creates a draft from the wing roots into student's (passenger) compartment. If fire necessitates a crash landing, open escape hatches just before landing."

1.17 Additional Information

Operating Limitations

When N9446Z was purchased by Air Chicago Freight Airlines, Inc., the operating limitations attached to the airworthiness certificate

were applicable to 8-26 rather than B-25 aircraft. However, this discrepancy was detected by the Director of Maintenance and B-25 limitations were obtained and followed.

This aircraft has been certificated under the provisions of **CAR Part 9** in limited category.

"1. This aircraft shall not be operated in any manner which will endanger public life and/or property. The aircraft shall not be operated at a take-off weight in excess of that, which in the event of critical engine failure, will provide a safe margin of performance for existing operating conditions considering the takeoff area altitude, temperature, and terrain.

"2. This airplane must be operated at all times within the limitations set forth in Army Technical Order **No. 18 25T-N-1** except for limitations specifically called out in Aircraft Specification A1-2, in which case values given in the specifications must be observed. A copy of pertinent Army Technical Orders and Aircraft Specification A1-2 must be carried during flight.

"3. Persons and/or cargo shall not be carried for compensation or hire.

"4. Seats and safety belts shall be provided for all occupants.

"5. If aircraft is to be operated in any other configuration than originally certificated, re-certification will be required."

1.18 New Investigation Techniques

None

2. ANALYSIS

Evidence indicates that an in-flight fire in the left engine caused the emergency. The **No. 1** piston assembly fractured and the rear master rod assembly separated causing a large perforation of the **No. 1** cylinder barrel. The perforation allowed escaping oil to be ignited on contact with the exhaust pipes which would have been at maximum temperatures during takeoff. The Safety Board did not determine the reason for the failure.

The initial damage to the engine's structure -- the disruption of the crankcase main section and the penetration of the **No. 1** cylinder barrel -- was of such magnitude that the engine's oil system became totally depleted in a relatively short time. Once the oil was ignited, flames and smoke propagated rearward, either below or above the engine nacelle's structure.

Since power absorption is a function of blade angle, propeller rpm, and airspeed, engine power output at a corresponding airspeed can be computed. Consequently, propeller performance calculations were made using a blade angle of 34°, propeller rpm of 2,400, outside air temperature of 71° F., and 30.10 inches of barometric pressure.

Calculations indicate that, at impact, the right engine was developing near maximum power (in excess of 1,700 brake horsepower) at an airspeed of about 209 mph. Performance data indicate that the aircraft was capable of climbing at 600 fpm with one engine inoperative and its propeller feathered. The minimum safe single engine speed is 145 mph.

In view of these data, the Safety Board concludes that the failure of the left engine was not, in itself, the cause of the accident.

Based on witness reports, the Safety Board believes that flames propagated downward and, subsequently, reached into the bomb bay area. Once flames and smoke had entered the bomb bay, airflow patterns allowed smoke and possibly heat to permeate the crew compartment.

The flow of smoke into the cockpit area was intensified when the crew opened their side windows. Army Technical Order 1B-25(T) N-1 warns against opening the pilot's side windows during an engine fire, since doing so creates a draft from the wing roots into the fuselage. Whether the crew was familiar with the warning, or whether conditions in the cockpit became so intolerable that they chose to disregard this warning, could not be determined.

Evidence suggests that conditions in the cockpit had deteriorated to such a degree that the crew was not able to control the aircraft. No apparent effort was made to change the pitch attitude of the aircraft or to reduce power on the right engine before impact. Additionally, witnesses stated that both pilot and copilot were seen waving their arms out the window.

There was no evidence of fire in the cockpit before impact; however, the pilot had been burned. Post-mortem examination did not conclusively establish how or when the pilot sustained these burns.

Reasons why neither pilot exhibited searing of their trachea or high levels of carbon monoxide levels in their blood could not be established. It is concluded that the crew's vision and possibly their breathing were inhibited by combustion products in the cockpit and that the side windows were opened to alleviate this condition.

Records concerning the history and maintenance of the aircraft were either incomplete or missing. However, it was determined that the engines were neither preserved nor run up during a 2-year period after the purchase of the aircraft by Air Chicago Freight Airlines, Inc., or at any specified time before the purchase.

Preservation of an aircraft engine before extended periods of inactivity **is** essential in order to prevent internal corrosion. Likewise, the engine should be preoiled, before the initial start, following such a period. Preoiling the engines **is** intended to provide adequate lubrication during initial start after prolonged periods of idleness.

Analysis of oil samples taken after the accident disclosed that the oil in both engines contained high concentrations of wear metals and corrosion products. The Safety Board concludes that failure to preserve or preoil the aircraft's engine during periods of inactivity can result in the initiation of multiple internal failures which can be catastrophic.

The Safety Board also believes that this lack of compliance with manufacturer's recommendations regarding preservation and preoiling of engines contributed factor to the initiation of the accident sequence.

3. Conclusions

3.1 Findings

1. The aircraft and crewmembers were properly certificated for the flight.
2. The gross weight and center of gravity of the aircraft were within allowable limits.
3. There was no evidence of an in-flight structural failure of the airframe or of the flight control system.
4. The engines were not preserved before a prolonged period of inactivity, and they were not preoiled before operation.
5. The left engine sustained a massive internal failure that resulted in the perforation of the No. 1 cylinder barrel by a section of a separated master rod assembly.
6. Oil from the left engine ignited when it contacted the exhaust system.
7. The left engine's fire extinguisher was discharged.
8. The fire was not contained within the power section of the left engine and propagated rearward and inboard.
9. The cockpit windows were opened in flight.
10. The cockpit environment was subjected to combustion products which impaired the crew's ability to function normally during an emergency.

11. Soot patterns **on** the aircraft's exterior confirmed the existence of an in-flight fire.
12. The right engine was producing near maximum power and the aircraft's single engine performance was not a factor in the accident.
13. No oxygen or smoke masks were installed in the aircraft nor were they required.

3.2 Probable Cause

The National Transportation Safety Board determines that the probable cause of the accident was the deterioration of the cockpit environment, due to smoke to the extent that the crew could not function effectively in controlling the aircraft under emergency conditions. The smoke and fire, originating from a massive failure in the power section of the left engine, propagated into the bomb bay area and then into the cockpit. The inspection system utilized was not effective in detecting the impending engine failure.

4. SAFETY RECOMMENDATIONS

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

- (1) Expand the program currently in effect in your Southern Region to include vintage and military surplus aircraft and rotorcraft, and develop similar programs within all FAA Regions. (Class 11-Priority Followup.) (A-77-18.)
- (2) Review existing maintenance requirements to determine that those in effect are sufficient to assure the maximum level of safety in the operation of surplus and vintage aircraft and rotorcraft. (Class 11-Priority Followup.) (A-77-19.)

BY THE NATIONAL TRANSPORTATION SAFETY BOARD

/s/ WEBSTER B. TODD, JR.
Chairman

/s/ KAY BAILEY
Vice Chairman

/s/ FRANCIS H. McADAMS
Member

/s/ PHILIP A. HOGUE
Member

/s/ WILLIAM R. HALEY
Member

April 14, 1977

5. APPENDICES

APPENDIX A

INVESTIGATION AND HEARING

Investigation

The National Transportation Safety Board was notified of the accident at 1640 e.s.t. on August 6, 1976. An investigation team went immediately to the accident site. Parties to the investigation were: Federal Aviation Administration and Air Chicago Freight Airlines, Inc.

No public hearing was held.

APPENDIX B

CREW INFORMATION

Instructor Pilot John B. Worley

Mr. Worley, 46, held Commercial Pilot Certificate No. 1321725, reissued January 29, 1976, with ratings for airplane single- and multi-engine land, instrument airplane, private privileges-glider, TB-25N (VFR only), and DC-B26 (VFR only). He also held a current Flight Instructors Certificate with an instrument rating for single- and multi-engine land aircraft.

Mr. Worley possessed a Class-II Medical Certificate, dated April 5, 1976, without limitations. Pilot log books were not recovered.

Mr. Worley's total flight time in B-25 type aircraft or his recency of experience could not be determined. His airman's medical records and his medical application, dated April 5, 1976, showed 4,806 flight-hours with 180 flight-hours in the previous 6 months.

Mr. Worley was not an employee of Air Chicago, but was hired on August 2, 1976, for the sole purpose of providing instruction to Mr. Schons.

Copilot Kenneth H. Schons

Copilot Kenneth H. Schons was employed by Air Chicago, October 14, 1975, as Director of Operations and Chief Pilot. Mr. Schons, 51, held Airline Transport Pilot Certificate No. 479228 with type ratings in Convair 240/340/440 and DC-3 aircraft.

He had accumulated 8,247 flight-hours, 136 hours of which were in the B-25. Dates of the B-25 flight time were not listed. Seven hours were flown by Mr. Schons during the preceding 90 days.

Mr. Schons had a First-class medical certificate without limitations.

APPENDIX C

AIRCRAFT INFORMATION

The aircraft was a North American **TB-25N**, serial No. 44-30737. Total time on the airframe was estimated at 2,513 hours. The engines were Curtiss Wright R-2600-35. The serial number of the left engine was not determined and that of the right engine was 192-207. Time since major overhaul of each engine was about 175 hours. Engine total times were unknown.

The propellers were Hamilton Standard model 23E50-473, Times since overhaul and total times of the propellers were undetermined.

APPENDIX D

Phoenix Chemical Laboratory, Inc.

FUEL AND LUBRICANT TECHNOLOGISTS

3953 SHAKESPEARE AVENUE

CHICAGO, ILL. 60647

September 10, 1976

RECEIVED FROM National Transportation Safety Board
Bureau of Aviation Safety
Washington, DC 20594

SAMPLE OF As shown below LABORATORY NO. 6 8 9 13-15
6 8 12-14

MARKED As shown below

Laboratory Number	Sample Of	Marked
6 8 9 1 3	New Oil	Texaco Bulk N9446Z
6 8 9 1 4	Used Engine Oil	Right Engine N9446Z
6 8 12 14	Used Engine Oil	Left Engine N9446Z
6 8 9 1 5	Aviation Gasoline	Air Chicago Truck N9446Z

The two used oil samples (Lab. Nos. 6 8 9 14 and 6 8 12 14) were centrifuged in order to separate their oil and sludge fractions. The following results were obtained:

Laboratory Number	6 8 9 1 4	6 8 12 14
Oil, % v.	84.9	99.95+
Water, % v.	14.3	0.00
Sludge, % v.	0.8	Less than 0.05

The oil fractions of the used engine oil samples and the new oil sample (Lab. No. 6 8 9 13) were then subjected to analysis as indicated below. The samples were analyzed for all metals found in the sludge samples plus the common additive elements, zinc, barium and magnesium.

Phoenix Chemical Laboratory, Inc.

FUEL AND LUBRICANT TECHNOLOGISTS

3953 SHAKESPEARE AVENUE

CHICAGO, ILL. 60647

September 10, 1976

RECEIVED FROM National Transportation Safety Board

SAMPLE OF

LABORATORY NO. 6 8 9 13-15
6 8 12 14
Continued

MARKED

Laboratory Number	6 8 9 1 4 Sludge	6 8 12 14 Sludge
Chromium, %	0.19	0.21
Magnesium	0.16	0.072
Nickel, %	0.070	0.24
Manganese, %	0.045	0.045
Barium, %	0.011	0.020
Molybdenum, %	0.020	0.034
Silver, %	0.007	0.076

Emission Spectrographic Analysis

Laboratory Number	6 8 9 14 Sludge	6 8 12 14 Sludge (note 3)
Base	Lead, Iron, Silicon	Lead, Iron, Aluminum
Major.. ..	Aluminum, Copper, Calcium, Chromium	Copper, Silicon
Minor	Phosphorus, Sodium, Molybdenum, Nickel, Manganese	Calcium, Manganese, Chromium
Trace.....	Silver	Magnesium

Phoenix Chemical Laboratory, Inc.

FUEL AND LUBRICANT TECHNOLOGISTS

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SAMPLE OF _____ LABORATORY NO. 6 8 9 13-15
 6 8 12 14
 MARKED _____ Continued

Laboratory Number	6 8 9 1 3	6 8 9 1 4	6 8 12 14
	New Oil	Used Oil Fraction	Used Oil Fraction
Viscosity @ 100 deg. F., cs.	256.6	263.4	260.6
Viscosity @ 210 deg. F., cs.	20.73	20.56	20.78
Viscosity Index	102	99	101
Total Acid No. mg, KOH/gram	0.02	0.70	0.13
Total Base No. mg, KOH/gram	0.00	0.00	0.00
Water, ppm	56	261	267
Ash, %	0.009	0.11	0.07
Sulfur, %	0.18	0.19	0.19
Nitrogen, %	0.03	0.07	0.06
Phosphorus, ppm	27	0	0
Chlorine, %	0.000	0.061	0.01
Lead, ppm	Not Detected (Less than 0.04)	525	319
Iron, ppm	1.2	138	65
Aluminum, ppm	0.76	25	38
Copper, ppm	0.13	26	13.1
Sodium, ppm	2.0	10	4.1
Calcium, ppm	1.9	5.7	5.0
Zinc, ppm	0.11	5.8	1.6
Chromium, ppm	Not Detected (Less than 0,004)	4.2	1.9

Phoenix Chemical Laboratory, Inc.

FUEL AND LUBRICANT TECHNOLOGISTS

3053 SHAKESPEARE AVENUE

CHICAGO, ILL. 60647

September 10, 1976

RECEIVED FROM National Transportation Safety Board

SAMPLE OF

LABORATORY NO. 6 8 9 13-15
6 8 12 14
Continued

MARKED

Comments

On the basis of the data which have been obtained it **is** possible to make the following comments:

- (1) Although the separated oil fractions of the used engine oils (Lab. Nos. 6 8 9 14 and 6 8 12 14) are but slightly oxidized, (cf total acid numbers, viscosities, pentane and benzene insolubles and infrared analysis) they contain large amounts of wear and/or corrosion products.
- (2) The separated oil fractions contain less phosphorus, but significantly more chlorine (especially Lab. No. 6 8 9 14) than the new oil sample. The nitrogen contents of the separated oil fractions are significantly elevated above that of the new oil. The sulfur contents of the separated oils are about the same as that of the new oil.
- (3) The lubricities of the separated oils, as measured by the four ball wear test and load wear index, are about the same as that of the new oil.
- (4) Although the presence of water in the used engine oils and sludge samples is not regarded as unusual, the high chloride content of the water and the sludge **is** noteworthy. By comparison, the chloride content of a sample of Chicago city water was found to be 13.1 ppm.

Phoenix Chemical Laboratory, Inc.

FUEL AND LUBRICANT TECHNOLOGISTS

3953 SHAKESPEARE AVENUE

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Comments Continued:

- (5) As expected the sludge sampias obtained from the used engine oils give evidence of extreme oxidation. This fact, combined with the lack of oxidation of the separated oil samples themselves, suggests that the sludge is not derived ~~from~~ the last samples of oil recovered from the engines in which the sludge was formed.
- (6) High concentrations of wear metals corrosion products, metal chips, silica, complex silicates, carbonates and other inorganic species are found in the sludge samples.
- (7) Sludge sample (Lab. No. 6 8 9 14) **contains** large amounts of nitrogen, phosphorus and chlorine. While the phorphorus may have precipitated from the new oil, there **is** no evidence to suggest that the new oil is the source of the nitrogen and chlorine components of the sludge.
- (8) Except for a trace of acidity in the distillation residue, the gasoline sample (Lab. No. 6 8 9 15) is generally satisfactory.

/s/ A.A. Krawetz