Boeing 767 GLIDER
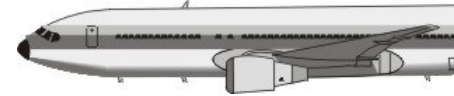
WHAT VALUE A FLIGHT ENGINEER?

Fuel calculations are part of the daily routine of hundreds of pilots, dispatchers and flight engineers across the country. Once in a while numbers get mysteriously transposed inaccurately, leading to a serious occurrence. Who does not remember the "Gimli Glider," a new Boeing 767 that was flying across the country when it ran out of fuel midway through the flight and glided safely to the Gimli airfield in Manitoba, Canada, then being used as a drag strip? Or the Boeing 707 that flamed-out and crashed on Long Island, New York, after being placed in a holding pattern by air traffic control (ATC) three times, for a total of about 1 hr. and 17 minutes? In that case, the investigation determined that the Captain had failed to communicate an emergency fuel situation to ATC before fuel exhaustion occurred.

Circumstances differ among fuel starvation cases, but the common denominator for almost all occurrences are errors or omissions by the pilot-in-command (PIC)..

Fuel quantity is usually measured by weight, gallons, or litres added, looking at cockpit gauges, using dipsticks, conducting visual inspections, monitoring in-flight fuel consumption, in time, or taking the word of a "reliable" third party who oversaw the fueling operation.

Computer programs and fuel tables are also widely used to calculate fuel requirements. Using only one

of the above methods may give some confidence in the fuel quantity, but combining two or more would considerably increase the accuracy.

During flight planning, crews must balance fuel requirements with passengers and cargo weight, which means that the aircraft is rarely filled to capacity. Airlines have a fuel policy that meets or exceeds the regulations but that will usually ensure that the aircraft has just enough fuel to meet the minimum fuel requirements.

Air carriers are conscious of their bottom line and always make sure that they do not carry around extra fuel that is not needed. However................

By Peter Banks

It was a smooth flight as Air Canada 143 made its way from Montreal to Edmonton on the afternoon of July 23, 1983. Below were cottony clouds, ahead only blue sky and clear air. The Boeing 767 cruised at 469 knots, nearing a route checkpoint at Red Lake, Ontario.

In the cockpit, Captain Robert Pearson chatted amiably with his first officer, Maurice Quintal. The two men were among only a handful of pilots trained to fly the twin-engine 767, then the most advanced jetliner in the world. "Everything's straightforward once you learn it," Pearson told Quintal, nodding toward the plane's sophisticated instrument panel. The 767 had indeed simplified a pilot's life.

Computer screens replaced dozens of instruments. The easy-to-read displays reduced pilot fatigue on long flights. On this four-hour trip to Edmonton, Pearson expected to relax a bit as he carried his 61 passengers to western Canada.

But his calm was broken suddenly as the plane passed over Red Lake. A warning

buzzer gave four quick beeps, and an amber light flashed. Quintal glanced at the

indicators in front of him. "Something's wrong with the fuel pump."

"Left forward fuel pump," Pearson added. "I hope it's just the fuel pump failing, I'll

tell you that."

The 767 has three fuel tanks, one in each wing and one in the plane's belly. For

each tank, two pumps deliver a steady stream of fuel to the engines. The warning

told Pearson and Quintal that the forward pump in the left wing was not working.

This could mean that the pump had failed, a fuel line was clogged, or that the left

tank was running dry—although the fuel load had been checked and rechecked

before takeoff.

Pearson consulted the plane's reference handbook, which said that normal flight

was possible with one defective fuel pump. A few seconds of wary calm passed.

Then more alarms sounded. The second pump in the left wing tank was also failing.

It was too much of a coincidence for two pumps to fail at the same time—it was

more likely that the left tank was running out of fuel.

"We've got to go to Winnipeg," Pearson said quickly, setting a course for the

nearest large airport. Quintal radioed air traffic control, and they received

immediate clearance to descend to 6,000 feet.

Pearson throttled back the engines and switched a computer monitor to display the

descent into Winnipeg. But he began to doubt that the plane could even make it there.

The cockpit crew grew tense as the 767 nosed down toward the clouds below.

More beeps blared the worst possible news: all four remaining fuel pumps were

now failing. Pearson maneuvered the aircraft gently, trying to preserve every trace

of fuel. Then the left engine stopped running.

Quintal radioed Winnipeg. "We've lost our number one engine." Preparing for a

possible crash landing, he added, "We'll require all the trucks out."

The pilots set the flaps for the single-engine landing, hoping in spite of what they

were witnessing that enough fuel remained. But as they passed 26,000 feet, the

remaining engine stopped. The cockpit became quiet. The computer screens

flickered off. Without power, the high-tech displays were dark and useless.

One hundred miles from Winnipeg, the massive jetliner was left with no electronic

instruments and with fewer controls than a small single-engine plane. The world's

most advanced aircraft was now a glider. The unthinkable had happened: Flight

143 had run out of fuel.

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How? How does a modern jetliner—equipped with the latest technology and

piloted by skilled people—run out of fuel at 26,000 feet? As with most air

disasters, there was no single cause. Flight 143 was brought down by a string of

errors in technology, communication, and training, but at the heart of the crisis was

a simple mistake in calculating the amount of fuel needed for the flight.

The plane's instruments should have quickly detected the error. The 767 boasts an

advanced fuel quantity processor that accurately gauges fuel on board. But, on this

particular plane, the fuel computer had never worked properly, and maintenance

workers lacked a spare computer.

Because the 767 was a new addition to Air Canada's fleet, the written maintenance

standards were still being revised. When the ground crew was preparing the plane

for departure from Montreal, they found that the fuel gauge did not work. A

maintenance worker assured Pearson—incorrectly—that the plane was certified to

fly without a functioning fuel gauge if the crew manually checked the quantity of fuel

in the tanks.

The manual procedure, known as a "drip," is as old as flying itself. Each fuel tank

contains a drip stick, which is similar to the dip stick used to check the oil in a car,

except that it is mounted upside down. When a mechanic under the wing loosens

the drip stick, it falls within the tank until a float at its tip bobs on the surface of the

fuel. The mechanic reads the depth of the fuel from markings on the drip stick, then

consults a handbook that gives the corresponding volume of fuel in the tank.

Before flight the drip stick is retracted into the wing and locked.

When unlocked on the ground, the top of the stick floats on the

surface of the fuel and the bottom drops below the wing and indicates

the depth of the fuel. The mechanic also records the fuel temperature

and the tilt angle of the aircraft if it is not parked on level ground.

Tables in the aircraft handbook convert these readings to fuel volume.

Two Air Canada mechanics, Jean Ouellet and Rodrigue Bourbeau, had performed

exactly this procedure on Flight 143 while it was on the ground in Montreal. They

measured a fuel depth of 62 centimeters (cm) in one wing tank and 64 cm in the

other. The manual showed that this corresponded to 3,758 and 3,924 liters (L) of

fuel in the tanks, for a total load of 7,682 L.

It would seem simple to subtract this amount from the amount needed for the trip to

get the amount that must be added to the tanks before take off. It would have been

simple, but for three small complications.

For years, Air Canada pilots had computed the amount of fuel they would need in

pounds, whereas the new 767's fuel consumption was expressed in kilograms. The

metric specifications were in accord with the Canadian government's plan to

introduce metric units nationwide. Secondly, the drip procedure told the pilots the

amount of fuel on board not in pounds or kilograms, but in liters.

What's more, on the earlier airplanes, the fuel had been calculated not by the pilot

or copilot, but by the third person in the cockpit, the flight engineer. The 767 did

not carry a flight engineer because the computers had reduced the cockpit

workload. Now, it was unclear whether the ground crew or the pilots were

primarily responsible for the fuel calculations.

Ouellet and Bourbeau knew that the flight to Edmonton, which called for a brief

stop in Ottawa without refueling, required 22,300 kilograms (kg) of fuel. Thus they

faced this problem: If 7,682 L of fuel remained in the plane, how many liters had to

be added to make a total of 22,300 kg? First Officer Quintal offered to help the

mechanics solve the problem. "The number of liters times the weight of a liter will

give you kilograms, right?" Quintal turned to a mechanic in charge of refueling and

asked for the factor for converting liters into kilograms.

"1.77," the refueller answered.

Using that factor, Quintal and the mechanics figured that the plane now contained

13,597 kg and would need 8,703 kg more to reach the required 22,300 kg. This

meant that the flight required an additional 4,917 L. The refueller added fuel, and

the mechanics repeated the drips until Pearson was satisfied that the plane was

properly fueled.

Unfortunately no one had asked the crucial question: What units go with the

conversion factor of 1.77? (See Crash Course in Density.)

After takeoff, Flight 143 made a short trip to Ottawa, where it stopped for 45

minutes without refueling. Then, with Quintal at the controls, the plane took off full

throttle, rocketing toward Edmonton. The confusion of the preflight calculations

seemed to slip away as the huge aircraft raced toward Red Lake.
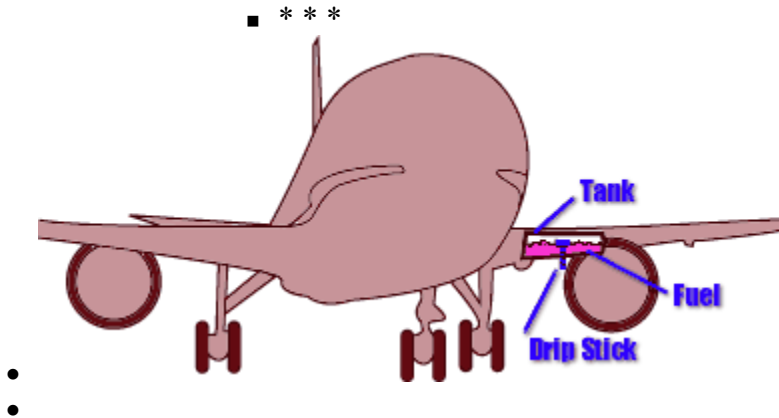
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- **As the plane glided powerless toward Winnipeg, the pilots and air traffic**

controllers made some hasty calculations and reached a grim conclusion. Without

engines, the craft's rapid descent would bring it in at least 10 miles short of the airport.

Pearson was directed to Gimli, an airport once used by the Royal Canadian Air

Force. Long abandoned by the Air Force, the airport had no control tower or fire

trucks. It was unsuitable for landing a 767, but no other airport was in gliding range.

Swooping quietly over Lake Winnipeg toward Gimli, Pearson realized that the

plane was coming in too high. The big plane would land too far down the runway

and skid off the end. In a desperate move to lose altitude, Pearson tried a side

slip—a maneuver used in small planes but unheard of in a jetliner. Turning the

wheel for a left turn and pushing the rudder for a right turn, the plane fought with

itself and descended faster.

When the plane tipped sharply onto its side, the passengers gasped in horror, as

they watched the ground grow closer in the windows. Then at the last moment,

Pearson righted the plane at the proper height. But the strip of concrete was no

longer a runway. It had been converted to a auto race track complete with fences,

race cars and spectators. People on the ground dove to get out of the path of the

rapidly descending plane.

The speeding 767 touched down at the right point, just 800 feet from the start of

the runway but blew out two tires and threatened to skid off the runway. Ahead

was a steel barricade that had been erected across the runway. Suddenly, the front

landing gear collapsed. The nose of the plane scraped along the runway throwing

dangerous sparks but dragging the plane slower. Miraculously the plane stopped

just in front of the barrier.

Fearing fire, the flight attendants rushed the passengers down the emergency

ramps. There were many scrapes and bruises but only a few real injuries. The

passengers and crew of Flight 143 had made it.

After the Boeing 767 was thoroughly repaired, Air Canada put it back into service.

Flight crews gave it an ignoble nickname but vowed that it will never earn that name

again. They call it the Gimli Glider.

They calculated:

Crash Course in Density

When you refuel a car, the gasoline is measured by volume in units of

gallons or liters. Because an airplane can lift only a certain amount of

weight, its fuel must be measured in pounds or kilograms.

When the ground crew conducted the drip procedure they determined

that the tanks contained 7,682 L. The crew knew that the flight required

22,300 kg, and they knew that volume should be multiplied by density to

obtain weight. But the density of jet fuel can be expressed in various units

such as pounds per gallon, pounds per liter, or kilograms per liter. The

ground crew used the value 1.77 without being certain of its units.

7,682 L x 1.77 = 13,597 kg of fuel remaining on board

22,300 kg needed − 13,597 kg on board = 8,703 kg to be added

8,703 kg ÷ 1.77 = 4,916 L of fuel to be added

If they had kept track of the units and verified that the units canceled properly, they could have calculated:

7,682 L x 0.803 kg = 6,169 kg remaining on board

22,300 kg needed − 6,169 kg on board = 16,131 kg to be added

16,131 kg x $\dfrac{\text{L}}{0.803\ \text{kg}}$ = 20,163 L of fuel to be added

The result was that they added about 5,000 L when they should have

added about 20,000 L. At the time of takeoff Flight 143 had about

10,000 kg of fuel—less than half the amount needed to reach Edmonton.

Why did the pilots and ground crew so readily accept the value 1.77?

Because, when accompanied by the proper units, it is a valid conversion

factor that they had all used in the past. The density of jet fuel is 1.77

pounds per liter.

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