During Adverse Conditions, Decelerating to Stop Demands More from Crew and Aircraft

Hydroplaning, gusting cross winds and mechanical failures are only a few of the factors that contribute to runway overrun accidents and incidents after landing or rejecting a takeoff. Improvements in tire design, runway construction and aircraft systems reduce risks, but crew training remains the most important tool to stop safely.

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by
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Decelerating an aircraft to a stop on a runway can become significantly more critical in adverse conditions, such as heavy rain in marginal visibility with gusting cross winds. Add the surprise of a malfunction, which requires a high-speed rejected takeoff (RTO) or a controlled stop after a touchdown on a slightly flooded runway, and a flight crew is challenged to prevent an off-runway excursion.

Research findings and technological advances in recent years have helped alleviate, but not eliminate, the hazards associated with takeoff and landing in adverse weather. The U.S. National Aeronautics and Space Administration (NASA) and the U.S. Federal Aviation Administration (FAA) conducted specialized tests on tire spin-up speeds after touchdown rather than spin-down speeds in rollout that confirm that hydroplaning occurs at substantially lower speeds than noted previously.

Significant advances have been made in optimization of aircraft traction performance on wet runways. Runway grooving and texturing with improved drainage have improved traction during wet-weather operations and the use of anti-skid braking devices, coupled with high-pressure tires, has reduced greatly the risk of hydroplaning. Still, accident and incident statistics confirm that several major runway overrun accidents each year are caused by unsuccessful braking involving either a high-speed landing or an RTO on a wet runway surface; the factors involved in decelerating to a controlled stop are very similar in these two situations.

Overrun Accidents Continue to Occur

A recent Boeing Company study reported that during 30 years of jet transport service there have been 48 runway overrun accidents with more than 400 fatalities resulting from RTOs and another 28 incidents which were potentially serious. The study also noted that these overrun accidents continue to occur with no apparent improvement in the rate at which they occur. Thus, while the probability of experiencing an RTO may appear rather remote in light of the statistics, individual pilots can expect to perform one or more high-speed RTOs during their flying careers; short-haul pilots will be more vulnerable to an RTO because they are exposed to a greater number of takeoffs.

Jet transport accident statistics confirm that one in every 3,000 takeoffs is rejected and approximately one-third of the RTOs are unsuccessful, resulting in serious overrun accidents or incidents. With some 15 million takeoffs per year (a rate of approximately 34 per minute each day) this historical rate can be expected to continue producing at least five RTO overrun accidents or incidents annually.

Studies indicate that about 80 percent of past RTO overrun accidents and incidents could have been avoided. Making a decision to abort a takeoff in the rather hectic environment of the flight deck while rapidly accelerating on the runway is not nearly as reliable as later contemplating the go/no-go factors while studying details of the situation around a conference table!

The Boeing study revealed that approximately 74 percent of the RTOs were non-engine related, although engine anomalies have been used traditionally to abort a takeoff in simulator training. Only 26 percent of the RTOs involved engine anomalies, followed by tire/wheel failure (24 percent) and aircraft configuration (13 percent). The remainder of the RTOs were attributed to bird strikes, crew coordination and other factors. It was noted that transferring control from first officer to captain played an important role in determining the outcome of an RTO.

After concluding that the great majority of RTO overrun accidents were preventable, the study noted that 58 percent of the events were initiated from speeds above V_1, the speed from which flight is normally continued. At this high speed, deceleration and stopping on the remaining runway is questionable even under ideal weather conditions; in one-third of the accidents wet or slippery runways were a major factor.

Hydroplaning Challenges Technology

Factors involved in hydroplaning have only been known for some three decades, and before then, wet runway accidents were blamed on the pilot. It seemed obvious that the pilot simply attempted to land at a much greater speed than that specified in the flight manual.

The first serious research in hydroplaning was conducted in the United Kingdom in 1956. That research referred to the uncontrollable skidding incidents on wet runways as "aquaplaning." Perhaps the most significant research breakthrough was made by NASA when it discovered that variable hydroplaning speed was directly associated with tire inflation pressure rather than the type of tire tread. NASA tests concluded that the higher the tire inflation pressure the higher would be the actual ground speed before hydroplaning developed. More recent tests revealed that landing on water-covered runways can result in hydroplaning at some 15 percent lower speeds than had been accepted as standard.

Manufacturers have produced higher pressure tires, coupled with other developments such as anti-skid braking devices and thrust reversers to improve the technology of all-weather high-speed jet landings.

Phenomenon Defined

Hydroplaning has been defined in technical terms in lengthy reports and reduced to formulas, and is being investigated continually. Simply stated, it is the condition under which pneumatic tires of aircraft [or highway vehicles] roll over fluid-, ice- or slush-covered pavements and hydrodynamic pressure begins to build between the tire footprint and the pavement. As the ground speed increases, the pressure grows larger, and at a critical speed hydrodynamic lift, resulting from the pressure under the tire, will equal the weight of the vehicle riding on the tire. When this occurs, hydroplaning speed has been reached. Any increase in speed above this critical value will lift the tire completely off the pavement, leaving it supported by the fluid alone; this is total-tire hydroplaning (also called the "water-skiing" speed) at or above which tires slide over fluid on the runway, making directional control difficult, nose wheel steering ineffective and braking or traction nonexistent.

Tire underinflation lowers normal hydroplaning speed by one knot for each two to three pounds below proper pressure. Underinflation can result from rapid descent from much colder altitudes as well as from careless servicing and insufficient preflight inspection.

New Formula Sets Reduced Speed at Which Hydroplaning Occurs

The velocity at which hydroplaning occurs is predictable and has been expressed in two mathematical formulas. The tire-ground contact pressure can be approximated by the tire inflation pressure. Using this in hydrodynamic formula leads to formula definitions for two separate situations. The first formula involves the spin-down speed of rotating tires and defines the hydroplaning speed to be equal to nine times the square root of the tire inflation pressure. This formula has been used for many years in computing probable hydroplaning speeds of various aircraft, based upon specific tire inflation pressure, and is still applicable in aborted takeoff situations.

The second formula involves a more realistic situation of landing or touching down on a wet runway where the water depth is greater than the tire-groove depth. In this situation with non-rotating tires, the spin-up speed when hydroplaning occurs is only 7.7 times the square root of the tire inflation pressure.

With the first formula for example, using a tire inflation pressure of 100 pounds, the hydroplaning speed would be 90 knots; with the second formula, the hydroplaning speed would be 77 knots. To enable greater margins and prevent hydroplaning, most jet-powered aircraft are equipped with main tire pressures of at least 150 to 200 pounds per square inch (psi).

An example of spin-up hydroplaning on a flooded runway involved a Gates Learjet 35 and was reported in the June 1992 *Flight Safety Digest*. The accident occurred during a second night-landing attempt during a thunderstorm. The pilot was unable to stop or maintain directional control because of hydroplaning and the aircraft went off the runway, resulting in substantial damage to the aircraft; however, there were no injuries. A water-covered runway, inadequate hazard notification, rain and a cross wind were factors that contributed to the accident.

NASA Distinguishes Three Types of Hydroplaning

NASA has distinguished three types of hydroplaning: (1) Dynamic hydroplaning, which occurs when there is standing water on the surface; (2) Viscous hydroplaning, which occurs when the runway surface is damp or wet; and, (3) reverted-rubber hydroplaning, which occurs when the rubber of a tire becomes sticky and tacky (reverting to a condition similar to its original uncured state) caused by steam generated by friction between the tire footprint and wet runway surface.

Dynamic hydroplaning occurs when $^1/_{10}$ inch or more of water on the runway acts to lift the tire off the runway and the tire is supported by a film of water.

Viscous hydroplaning occurs when a very thin film of fluid, $^1/_{1000}$ inch or so, cannot be penetrated by the tire, and the tire rolls on top of the film. This can occur at much lower speeds than dynamic hydroplaning, but requires a smooth or smooth-acting surface.

Reverted-rubber hydroplaning requires a prolonged locked-wheel skid, reverted rubber and a wet runway surface. Reverted rubber acts as a seal between the tire and the runway and delays water exit from the footprint area. The water heats and is converted to steam and the steam lifts the tire off the pavement, leaving telltale white scrub marks on the runway. High-performance anti-skid braking systems prevent the locked-wheel configuration necessary for reverted-rubber hydroplaning.

Research Design Leads to Tire Changes

Recent NASA investigations of automobile tire hydroplaning reveal that in addition to inflation pressure, tire-footprint aspect ratio (footprint width divided by length) has a significant influence on the dynamic hydroplaning inception speed. Highway vehicle tire footprints differ from conventional bias-ply aircraft tire footprints in that the width dimension remains nearly constant for different loading conditions, whereas for aircraft tires footprint dimensions vary with loading, resulting in a relatively small range of aspect ratio values.

In addition to investigating tire tread ribs, grooves and footprint size, NASA is also investigating friction and wear properties of new aircraft tire construction, such as radial-ply types. These tires are compared to bias-ply construction and tests have been conducted using medium-size Boeing 737 and DC-9 tires.

The latest auto tire ("Aquatred") by Goodyear was developed to prevent hydroplaning during wet-weather operations. It incorporates a deep groove running down the center of the tread. The deep groove is designed to channel water, to improve traction and prevent hydroplaning. Runway grooving, which also prevents water buildup, accomplishes this function on airport runways.

Because of the different aspect ratio values of tire footprints, this innovation is not currently applicable to aircraft tires, but may be in the future.

Cross Winds Create Problems

One of the worst control situations occurs when there is a cross wind in conjunction with fluid- or slush-covered runways, which can reduce greatly tire traction and contribute to hydroplaning. Cross winds produce side forces which tend to push the aircraft off the downwind side of the runway. These forces are proportional to the square of the cross-wind velocity; thus, a 10-knot cross wind would quadruple the side force developed by a five-knot cross wind on an aircraft.

A review of landing accidents reveals there were many more incidents of hydroplaning involving aircraft excursions off the side of runways than at the end, and cross winds were usually involved. In recent years, several hydroplaning accidents involving runway overrun, such as the Boeing 737 accident at LaGuardia Airport, N.Y., in 1989, were the result of high-speed aborted takeoffs. NASA is supporting FAA tests and evaluation of hard foam to extend runway overrun areas. A recent aviation industry survey reveals that approximately two-thirds of all U.S. civil airport runways have less than 1,000-foot overrun areas.

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Runway Grooving Reduces Skids

Runway grooving was developed by the British, acknowledged pioneers in texturizing runway surfaces. British experience dates to 1956, following an increase in skidding accidents involving military planes. The British grooved runways and it worked so well that they expanded the program beyond military fields to civilian airports. During the late 1960s, the United States began grooving runways at major air carrier airports and the program has been very successful in helping to curb runway excursion accidents. Because the process is expensive, very little emphasis has been placed on grooving U.S. general aviation airports.

In recent years, there are have been many types and configurations of grooving tested at various airports. One of the most interesting examples of grooving was the pattern developed for the NASA Kennedy Shuttle Landing Facility. The 15,000-foot runway was constructed initially with coarse texture and transverse grooves for its entire length. However, after five space shuttle landings, the tire spin-up wear was determined to be excessive. After comprehensive testing, the configuration of grooving at each end of the runway, where touchdown would occur, was changed to longitudinal grooving.

Pilots should be prepared for reduced braking action in the touchdown area at the opposite end of the landing runway.

In combating hydroplaning, engineers recognized two major factors which create the problem. In one circumstance, a wave of water builds under spinning tires so that the aircraft is actually separated from the runway. Grooving allows this rush of water to be carried away by what amounts to thousands of tiny gutters. Another situation is the film of water which exists between tire and runway under wet conditions. This film can measure only $^{1}/_{1000}$ – $^{2}/_{1000}$ inch thick, but NASA tests have demonstrated that at least 7,000 pounds of pressure per square foot is sometimes needed to penetrate it. Grooves break the glass-like slickness of the film in the same fashion as rough texture peaks do on concrete runways.

To help promote water drainage most runways are constructed with a cross slope, or crown, and coarse, high-textured surface finishes are applied. To a large degree, tire traction is dependent on the condition and texture of the pavement surface. Studies have shown that rubber accumulation on touchdown areas of a runway can significantly degrade aircraft deceleration. Pilots should be prepared for reduced braking action in the touchdown area at the opposite end of the landing runway.

Although the major air carrier airports have improved drainage and/or runway grooving, there are still many general aviation airports where this has not been accomplished. Business jet operators should confirm the condition of runways when flying to unfamiliar airports where wet weather is possible.

Braking Can Be Measured

In inclement weather conditions a pilot, after clearing the active runway, may have been asked to comment on braking action. This was a personal judgment and what might have been "braking action nil" by one pilot, might have been "fair to poor" by another. To standardize the condition of tire/runway friction, NASA has developed several ground friction measuring vehicles that provide comparable data with jet-powered test aircraft under varying runway conditions.

[Thomas J. Yager, the senior project engineer at NASA's Langley Research Center in Hampton, Va., wrote a comprehensive report [*Flight Safety Digest*, March 1989] that detailed the progress of the joint FAA/NASA Aircraft/Ground Vehicle Runway Friction Program. He described the use of various vehicle configurations used in establishing standardized braking friction coefficient values for various dry runway surface conditions as well as for water-covered, compacted-snow and ice-covered surfaces.]

Flight Crews Studied

There are differences between stopping an aircraft after a landing touchdown and an RTO because the RTO does not involve the approach segment, same aircraft configuration or crew mindset. Although there will be a difference in flap configuration between landing and takeoff, after touchdown the objective of decelerating and stopping will be the same.

In a pilot performance study conducted by Boeing in 1991, utilizing a Boeing 737 flight simulator, 24 line pilots were observed during various phases of rejected takeoffs.

Surprise events in the simulator included engine failures, fire warnings, system failure indications and blown tire indications. As a result of these observations, several specific training recommendations were made:

- A better crew understanding of V_1 speed is needed;
- Proper RTO braking techniques must be emphasized;
- Use of manual vs. automatic speedbrake deployment during RTOs must be examined;
- More attention is needed in training to blown and failed tires;
- Non-engine events should be introduced for RTO simulator training; and,
- The captain should make the go/no-go decision and, if necessary, execute the RTO.

The Boeing *Takeoff Safety Training Aid* was produced as a result of the pilot performance study. Some of the more significant training and operational recommendations are excerpted below:

- *High-Speed Callout:* All operators should adopt a callout which alerts crews to entry into the *high-speed/high-risk* regime of the takeoff roll.
- *V_1 Callout:* The V_1 callout must be made so that any decision to stop can be made (and stop actions initiated) *by* V_1.
- *RTO Actions:* Each operator should emphasize the proper order and timely application of retarding forces in execution of the RTO maneuver. Each operator should develop a standard callout which clearly and unambiguously announces initiation of the RTO maneuver.
- *RTO Autobrakes:* When available and operational, autobrakes should be set to the RTO position prior to takeoff roll.
- *Takeoff Briefing:* A runway-specific pretakeoff briefing, including a discussion of pertinent RTO considerations, is recommended prior to *each* takeoff.
- *The Meaning of V_1:* Each operator should include in its academic training program a discussion of the definition and fundamental applications of the concept of *V_1 speed* in modern jet transport performance.
- *Slippery Runway Performance:* Each operator should include in its training program a discussion of the effects of runway surface composition, surface contamination and adverse weather conditions on stopping performance of their aircraft types.
- *Reverse Thrust Performance:* Each operator should include in its training program a discussion of the contributions of reverse thrust and speedbrakes to stopping performance on dry and slippery runways.
- *Balanced-field RTO:* Each operator should demonstrate in its training program the effort required to perform a maximum-effort stop during a balanced runway-limited RTO from near or at V_1.
- *Warnings/Cautions/System Anomalies:* Each operator should address or demonstrate in its training program the proper crew actions when master cautions/warnings or system anomalies occur in the *low-speed* regime or the *high-speed* regime.
- *Tire Failures:* Each operator should address or demonstrate in its training program the proper crew actions with high-speed tire failure(s).
- *Braking Techniques:* Each operator should address or demonstrate in its training program the proper braking technique and pedal forces required to achieve maximum stopping performance.
- *Transfer of Airplane Control During an RTO:* Each operator should address or

A DC-3 Floats!

The author's unexpected introduction to hydroplaning came in 1960 after a DC-3 night landing during heavy rain at Harbor Field Airport in Maryland; the airport was built by filling in a section of Baltimore Harbor. The runways had very poor drainage and there were large areas where standing water was more than six inches deep.

When the runway lights became visible, I called for full flaps and touchdown was made near the end of the runway. The tail of the DC-3 settled down normally but there was no feeling of any braking action after applying full brakes. Even though the aircraft was moving at a very slow speed, it behaved as if it was skidding on a sheet of ice.

Because the runway ended with a drop-off into the harbor, I elected not to attempt a ground loop and allowed the aircraft to continue the very slow pace of 5 to 10 miles per hour (8 to 16 kilometers per hour) in hopes of still stopping. The DC-3 splashed into the harbor very gently and remained afloat. Passengers exited onto the wing to the ramp, while the copilot held the wing tip.

There were no injuries and the aircraft was only slightly damaged. During the night, the nose of the aircraft gradually submerged into the harbor's salt water, and corrosion became a major concern. The insurance company elected to replace the aircraft, but the submerged DC-3 was recovered, sold and refurbished to fly again.

The Civil Aeronautics Board (now the U.S. National Transportation Safety Board) investigated the accident and its representative was very impressed with the long telltale white wheel marks which extended most of the length of the 4,400-foot (1,320-meter) runway. He remarked that this was the best evidence of hydroplaning (then only a "phenomenon") he had ever seen. ♦

J.L.K.

demonstrate in its training program the importance of crew coordination before, during and after an RTO.

The Air Transport Association (ATA) and Aerospace Industries Association (AIA) Task Force recently made to the FAA nine specific recommendations:

1. Standardize accelerate-stop transition segment;
2. Provide wet runway accountability;
3. Provide worn brake accountability;
4. Provide line-up distance accountability;
5. Develop model operating procedures;
6. Develop model training procedures;
7. Improve simulator fidelity;
8. Provide runway condition reports; and,
9. Provide residual brake heat accountability.

The Task Force concluded that the greatest opportunities for improvements in safety are in training practices and operation procedures. ♦

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About the Author

Jack L. King was co-founder of Professional Pilot *and served as its part-time managing editor for 11 years. He has written articles for many aviation publications, and is the author of two books,* Corporate Flying, *and* Wings of Man, the Legend of Captain Dick Merrill.

King, a jet-rated pilot, was trained as a B-25 pilot during World War II and has accumulated more than 20,000 hours since 1939. After the war ended, he was a test pilot for the Glenn L. Martin Co., flying certification tests for Martin 202 and 204 transport aircraft. He then flew as a corporate chief pilot for more than three decades. He has air transport pilot (ATP), certified flight instructor (CFI) and airframe and powerplant (A&P) certificates.

Aviation Statistics

Fire-involved Accidents and Incidents Reviewed

—

by
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Data were used to develop an overview of aviation accident and incident causal factors and determine the number of these occurrences that involved fire and their respective causes.

All available factual accident and incident data throughout the 30-year period from Feb. 27, 1962, through March 31, 1992, were reviewed. The year 1962 is recognized generally as the beginning of the jet-transport age, when a significant number of the first-generation, high-density jet passenger transports were introduced into airline service.

The 30-year period produced records of 5,980 accidents and incidents. Causal factors involving pilot or other flight crew actions or inactions accounted for about 70 percent of the events. The majority attributed to flight crews can be characterized as follows:

- The aircraft did not remain within the confines of the runway during the landing phase;

- The aircraft was in a controlled flight into terrain or uncontrolled descent into terrain; or,

- There was improper use or interpretation of flight instruments.

Accidents and incidents not attributed to flight crews involved the following:

- Engine fires;

- Structural failures;

- Bird strikes;

- Flight-control malfunctions or failures;

- Uncontained engine failures;

- Wheel-well fires associated with tire and brake failures;

- Sabotage;

- Cabin interior fires; or,

- Hostile ground-to-air or air-to-air attacks.

A total of 250 (somewhat more than four percent; Appendix) of the events involved fire as the principal factor. The majority of these involved engine fires and smoke/fires with electrical system origins. One event (No. 139) involved self-immolation of a passenger.

Event No. 196 is the only accident which was attributed to a passenger's cigarette (cigarettes were also suspected to have been involved in events No. 144 and No. 118).

Two aircraft, the Boeing 707 (No. 118) and the Douglas DC-9 (No. 197), involved in the

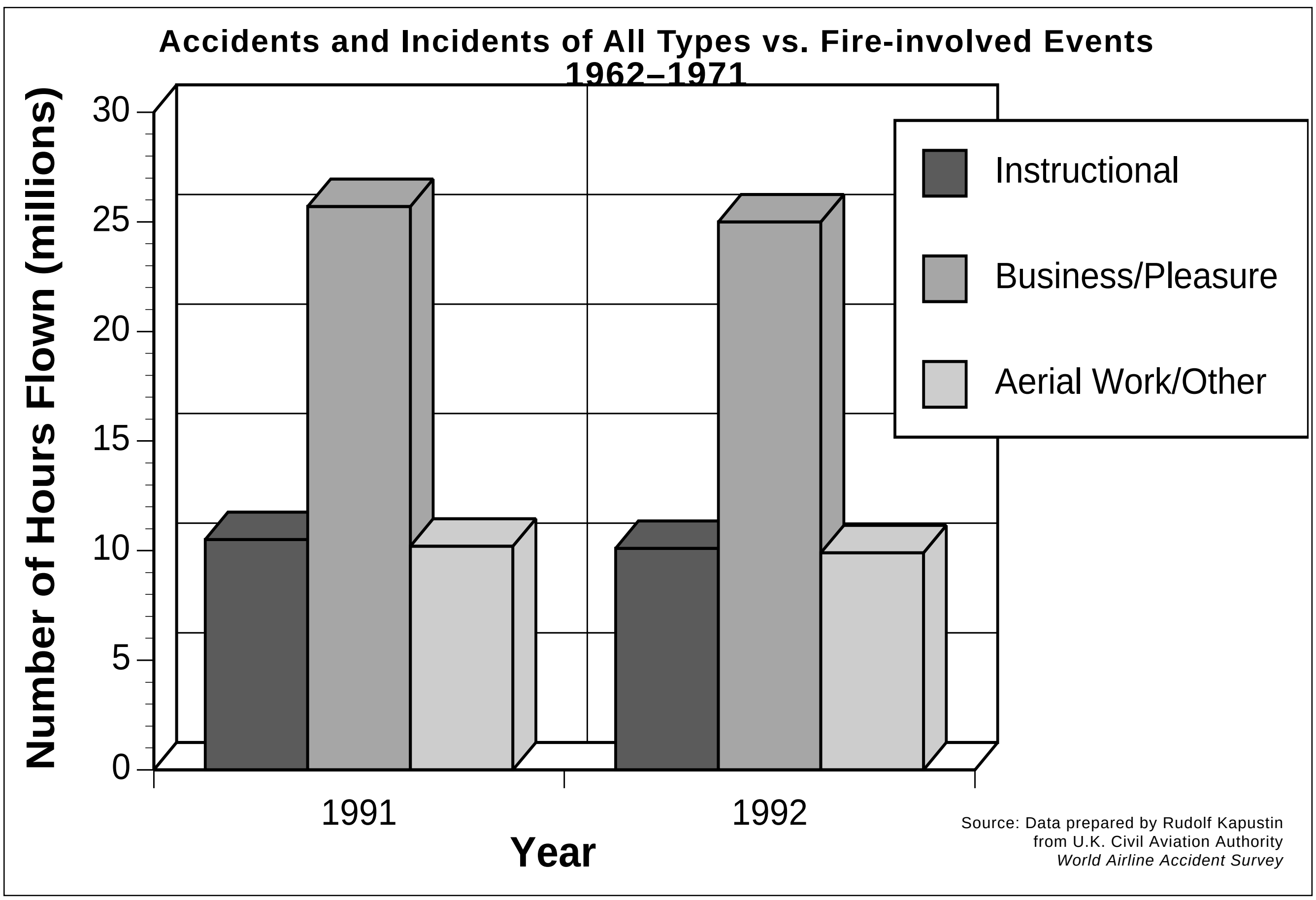

Figure 1

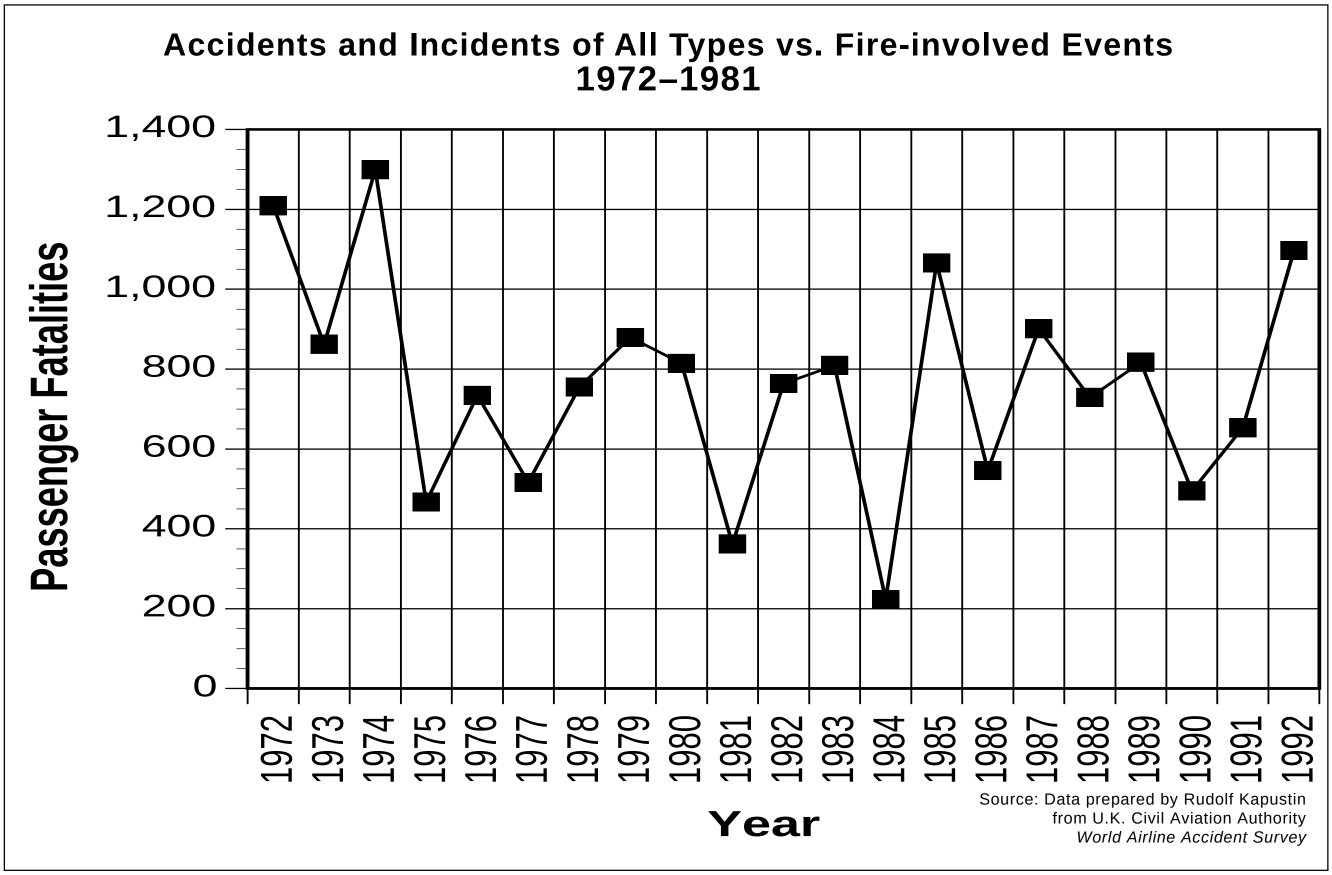

Figure 2

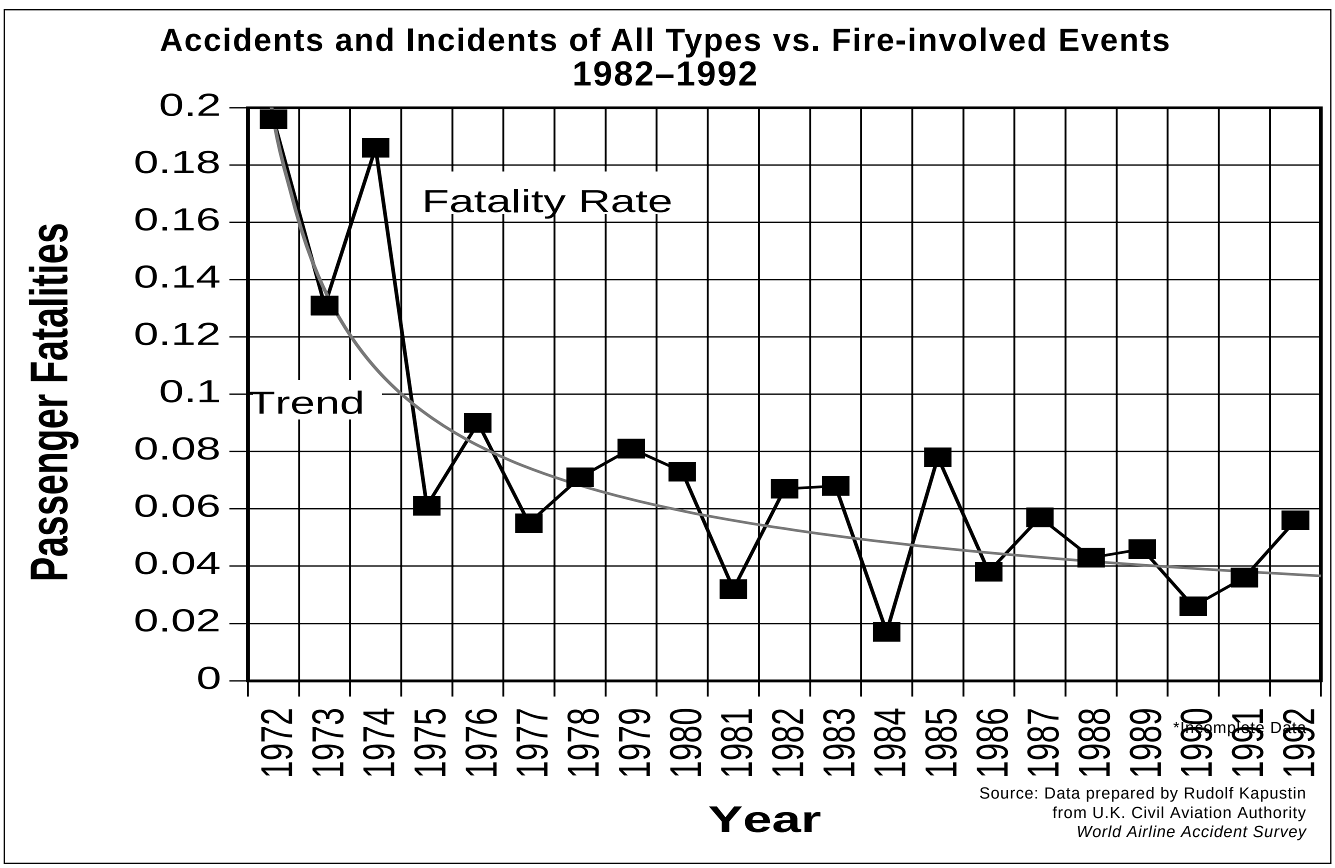

Figure 3

catastrophic in-flight cabin fire accidents were certificated under then-applicable provisions of U.S. airworthiness standards for transport category airplanes. These regulations included some requirements for flammability testing of cabin interior materials, but investigations of the accidents determined that the regulation requirements were inadequate.

The following are the most current and significant regulatory changes since these two in-flight fires:

- "Flammability Requirements for Aircraft Seat Cushions," Amendments 25-59, 29-23 and 121-184, October 26, 1984.
- "Airplane Cabin Fire Protection," Amendments 121-185, March 29, 1985.
- "Fire Protection Requirements for Cargo or Baggage Compartments," Amendments 25-60, May 16, 1986.
- "Improved Flammability Standards for Materials used in the Interiors of Transport Category Airplanes," Amendments 25-61 and 121-189, July 21, 1986.
- "Improved Flammability Standards for Materials used in the Interiors of Transport Category Airplanes," Amendments 25-66 and 121-198, August 25, 1988.

Also, the FAA has published the *Aircraft Material Fire Test Handbook* (DOT/FAA/CT-89/15), September 1990. This publication describes all FAA-required fire test methods for aircraft materials.

Nearly all aircraft accident fatalities that are not the result of crash/impact injuries are the result of post-crash fires and the inability to exit aircraft quickly, which in most cases is attributed to incapacitation from toxic smoke, fumes or injuries. A review and analysis of technical papers on aircraft cabin fire safety was conducted to determine the areas of principal concern and proposed resolutions of such concerns. It was found that flight and cabin crew labor organizations, regulatory authorities, air carriers and aircraft manufacturers support aircraft and cabin fire-safety improvements.

(This article was adapted from a report prepared by the author for Philip Morris International.) ♦

About the Author

Rudolf Kapustin has been involved in a wide range of air transport industry activities during the past 48 years, including airline maintenance with Trans World Airways (TWA), field service with Curtiss Wright, U.S. Federal Aviation Administration (FAA) production and type certification, and 24 years with the U.S. Civil Aeronautics Board, later the National Transportation Safety Board (NTSB), where he was investigator-in-charge of 47 major accidents.

For the past seven years he has been president and principal consultant of Intercontinental Aviation Safety Consultants, engaged in examining virtually every aspect of aviation accident causation, accident prevention and training of airlines and corporate operators in accident investigation procedures and emergency preparedness.

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Appendix

Summary of Fire-involved Accidents and Incidents

(Data compiled by Rudolf Kapustin)

Event No.	Date (M-D-Y)	Aircraft Type	Location	Operation	Circumstances (A) Accident (I) Incident
01	02-27-62	Canadair CL-44	United States	Flying Tiger	**(I)** Explosion in No. 1 engine, failure of high pressure turbine.
02	03-15-62	Lockheed L-1049H	Philippines	Flying Tiger	**(A)** Apparent midair explosion. Search failed to find any evidence of aircraft.
03	09-23-62	Lockheed L-1049H	Atlantic Ocean	Flying Tiger	**(A)** Ditched at sea after fire in No. 3 engine.
04	10-11-62	Hawker Siddeley Comet 4	England	BOAC	**(I)** Explosion in No. 3 engine when power applied at takeoff.
05	04-08-63	Vickers Viscount 806	Italy	BEAC	**(I)** In-flight fire in No. 1 engine.
06	05-03-63	Convair CV-340	Brazil	Cruziero	**(A)** Fire in No. 2 engine after takeoff.
07	09-04-63	Aerospatiale Caravelle	Duerrenaesh (?)	Swissair	**(A)** Fire on left underside of fuselage 4 minutes into flight.
08	11-01-63	Boeing 720	United States	Eastern	**(I)** Control tower advised of fire in No. 4 engine.
09	12-08-63	Boeing 707	United States	Pan Am	**(A)** Aircraft reported “going down in flames, lightning.”
10	01-09-64	Douglas DC-3	Argentina	A.L.A.	**(A)** Localized fire in cabin; resulted from fuel tanks being torn open.
11	03-26-64	Curtiss C-46	Brazil	VASP	**(A)** Fire in right engine; crashed into bay.
12	03-28-64	Douglas DC-4	Pacific Ocean	private	**(A)** Pilot reported fire in No. 2 engine. Aircraft lost at sea.
13	07-09-64	Vickers Viscount 745D	United States	United	**(A)** Aircraft was observed flying low, trailing smoke.
14	10-10-64	Curtiss C-46	United States	Capitol	**(I)** Left engine backfired and shut down.
15	11-19-64	Argosy AW650	United States	Zantop	**(I)** Fire caused by electrical element in the left horizontal stabilizer de-icer unit.
16	03-14-65	Aerospatiale Caravelle	United States	United	**(I)** In-flight fire in left engine.
17	03-25-65	Convair CV-440	United States	Mohawk	**(I)** Fire in rear baggage compartment.
18	05-03-65	Boeing 720B	United States	CAL	**(I)** Explosive sound and flash from No. 2 engine; subsequent failure of No. 1 engine.
19	06-09-65	Douglas DC-8	United States	National	**(I)** Fire in No. 1 engine; failure of fuel manifold.
20	06-28-65	Boeing 707	United States	Pan Am	**(I)** Explosion in No. 4 engine followed by fire.
21	08-04-65	Douglas DC-4	Panama	RAPSA	**(A)** Flames in No. 2 engine observed by tower controller.
22	08-04-65	Vickers Viscount 832	Australia	Ansett-ANA	**(I)** Failure of engine; intense fire prior to landing.
23	08-12-65	Curtiss C-46	Brazil	Paraense Transport	**(A)** Fire in left engine; left wing and engine broke away from fuselage; crashed.
24	10-04-65	Curtiss C-46A	Colombia	S.E.A.	**(A)** Flames observed from right wing and engine.
25	12-25-65	Douglas DC-8	United States	JAL	**(I)** Explosion and fire in No. 1 engine.
26	02-11-66	Nord 262A	United States	Lake Central	**(I)** Left engine shutdown because of turbine failure.
27	02-13-66	Boeing 720	United States	Braniff	**(I)** No. 1 engine burst into flames upon landing.
28	04-01-66	Douglas DC-3	United States	private	**(I)** Smoke observed in cockpit; subsequent fire observed in No. 2 engine.
29	04-14-66	de Havilland Heron 2E	England	BAC	**(I)** Fire in No. 3 engine and partial failure of No. 2 engine.
30	06-05-66	Hawker Siddeley HS-125	France	Air Affaires	**(A)** Fire behind jet engine enveloped entire plane; leaking fuel.
31	06-17-66	Convair CV-440	United States	North Central	**(I)** Explosion in No. 1 engine; failure of No. 6 cylinder.
32	07-07-66	Nord 262A	United States	Lake Central	**(I)** Explosion and fire in right engine; turbine section failure.
33	08-04-66	Nord 262A	United States	Lake Central	**(I)** Fire in left engine; failure of first-stage turbine wheel.
34	08-11-66	Nord 262A	United States	Lake Central	**(I)** Left engine flame out; failure of 3rd stage turbine wheel.
35	08-17-66	Curtiss C-46	Argentina	Aerovias Halcon	**(A)** No. 1 engine overheated; cargo jettisoned; crashed into water.
36	09-22-66	Vickers Viscount 832	Australia	Ansett ANA	**(A)** Fire in No. 1 and No. 2 engines; no cause determined.
37	10-19-66	Douglas DC-3C	Netherlands	n/a	**(I)** Fire in right engine.
38	10-30-66	Hawker Siddeley Comet 4C	Mexico	Mexicana	**(I)** Fire in engine No. 4.
39	12-16-66	Aerospatiale Caravelle	Greece	Air France	**(I)** Fire in No. 1 engine; fire spread.

Event No.	Date (M-D-Y)	Aircraft Type	Location	Operation	Circumstances (A) Accident (I) Incident
40	12-17-66	Vickers Viscount	Canada	Air Canada	**(I)** Fire in No. 3 engine.
41	01-??-67	Britania	Cuba	Cubana	**(I)** High temperature in No. 2 engine; fire in nacelle.
42	02-10-67	Lockheed L-1049H	Vietnam	Flying Tiger	**(I)** No. 2 engine and propeller separated during flight.
43	03-24-67	Douglas DC-3C	United States	corporate	**(I)** Fire in flight; fuel leaking from auxiliary power unit ignited and set fire to cargo.
44	04-08-67	Douglas DC-8	United States	Eastern	**(I)** Fire in No. 2 engine shortly after takeoff; aircraft returned to airport.
45	04-30-67	Boeing 727	United States	Continental	**(I)** Engine fire en route.
46	06-01-67	Hercules (?)	Tanzania	Zambian Air Cargoes	**(I)** Fire in wheel well and takeoff rejected.
47	06-13-67	de Havilland DH-113	United States	air taxi	**(I)** No. 3 engine failed.
48	06-23-67	British Aircraft Corp. BAC 1-11	United States	Mohawk	**(A)** Fire and smoke from tail; aircraft crashed.
49	06-24-67	Convair CV-880	United States	Delta	**(I)** Fire in No. 4 engine while climbing.
50	07-11-67	Gulfstream G1	United States	corporate	**(A)** Fire in one, possibly two engines; crash landing, explosion and crash.
51	07-23-67	Convair CV-340	United States	Braniff	**(I)** Fire in flight caused by failure of No. 8 cylinder.
52	07-31-67	Vickers Viscount	United States	Aloha	**(I)** Fire in flight; continued to airport to land.
53	08-09-67	Dakota	Scotland	Cambrian	**(I)** Right engine fire warning.
54	09-01-67	Douglas DC-9	Japan	Korean Airlines	**(I)** Total electrical failure.
55	09-09-67	Boeing 707	Germany	Pan Am	**(A)** No. 3 engine fire; 14th stage compressor disc failure.
56	11-11-67	Boeing 707	Greece	Olympic	**(I)** Fire in No. 2 engine while climbing; aircraft returned safely to airport.
57	11-21-67	Boeing 707	United States	BOAC	**(I)** Explosion and fire under right wing.
58	01-27-68	Ilyushin IL-18	Italy	LOT	**(I)** Engine explosion damaged wing; safe landing.
59	03-30-68	Lockheed L-1049	Panama	RAPSA	**(A)** Crash shortly after takeoff; fire in No. 3 engine.
60	04-08-68	Boeing 707	England	BOAC	**(A)** Fire in No. 2 engine; engine fell off; fuel tanks exploded.
61	05-02-68	Carvair	n/a	Aer Lingus	**(A)** Multiple engine failures; fire.
62	08-05-68	Boeing 707	United States	Flying Tiger	**(I)** Fire in No. 4 engine; fuel line fitting separation.
63	09-11-68	Aerospatiale Caravelle	France	Air France	**(A)** Engine fire following takeoff; crashed into ocean.
64	11-19-68	Boeing 707	United States	American	**(I)** Explosion in No. 1 engine.
65	02-09-69	Boeing 727	Germany	Pan Am	**(I)** Rejected takeoff because of explosion and fire in No. 3 engine.
66	04-02-69	Curtiss C-46	Bahamas	freight	**(A)** Crashed into ocean following possible fire on board.
67	04-07-69	Vickers Viscount	Canada	Air Canada	**(A)** Fire in wheel well caused by overheating of starter selector relay.
68	07-26-69	Aerospatiale Caravelle	Algeria	Air Algeria	**(A)** Fire in electrical compartment; aircraft crashed and destroyed.
69	08-17-69	British Aircraft Corp. BAC 1-11	Germany	Laker	**(A)** Fire in flight; probable electrical discharge in vicinity of radio antenna lead.
70	11-27-69	British Aircraft Corp. BAC Super VC10	England	BOAC	**(I)** Failure in No. 3 engine; damage to No. 4 engine; safe landing.
71	11-28-69	Douglas DC-8	United States	Eastern	**(I)** Fire warning on No. 4 engine; rejected takeoff.
72	12-22-69	Douglas DC-6B	Vietnam	Air Vietnam	**(A)** Explosion near left cabin washroom; emergency landing and fire.
73	01-22-70	Vickers Viscount	England	British Midland	**(I)** Explosions and fire in No. 4 engine.
74	02-21-70	Convair CV-990	Switzerland	SwissAir	**(A)** Explosion following takeoff bomb on board.
75	02-22-70	Curtiss C-46	United States	COOPSEA	**(I)** Backfiring and fire in left engine.
76	03-06-70	Jetstream	Switzerland	Bavaria Flug.	**(A)** Engine fire; crashed through high-tension power line.
77	03-14-70	Antonov AN-24	Egypt	n/a	**(I)** Explosion and fire in left engine nacelle.
78	05-06-70	Vickers Viscount	Somalia	Somali Airlines	**(I)** Failure of flight controls; fire.
79	06-10-70	Ambassador 2	France	Dan Air	**(I)** Explosion in wheel well; loss of electrical power.
80	06-16-70	Boeing 727	United States	Eastern	**(I)** Fire in No. 3 engine; failure of 11th stage compressor disc.
81	06-22-70	Boeing 707	England	BOAC	**(I)** Fire in No. 1 engine; fatigue crack in front spacer.
82	07-13-70	Douglas DC-7	United States	Ortner Air Service	**(I)** Fire in No. 3 engine; fuel leak into nacelle.
83	07-26-70	Douglas DC-7C	Ivory Coast	AHCO	**(I)** Fire in No. 3 engine.
84	08-17-70	Boeing 747	Canada	Air France	**(I)** Separation of turbine disk rim; fire in No. 3 engine.
85	09-18-70	Boeing 747	United States	American	**(I)** Explosion and fire in No. 1 engine.
86	10-30-70	Boeing 707	France	Air France	**(I)** Explosion and fire in No. 3 engine.

Event No.	Date (M-D-Y)	Aircraft Type	Location	Operation	Circumstances (A) Accident (I) Incident
87	11-27-70	Aerospatiale Caravelle	Romania	AUA	**(I)** Engine fire and failure; safe landing.
88	12-19-70	Antonov AN-22	Panagarsh (?)	Aeroflot	**(A)** Engine fires; crashed at landing.
89	12-22-70	Boeing 720	Iceland	Trans-Polar	**(I)** Explosion and fire in No. 4 engine.
90	01-10-71	Twin Pioneer	Iraq	n/a	**(I)** Disintegration of left engine; smoke filled aircraft; safe landing.
91	01-13-71	Douglas DC-9	Netherlands	KLM	**(I)** Explosion in right engine at takeoff.
92	04-10-71	Gates Learjet 23	United States	corporate	**(I)** Thermal runaway of right hand battery.
93	04-11-71	Gates Learjet	United States	n/a	**(I)** In-flight fire electrical failure.
94	05-09-71	Fokker F27	United States	Phillips Petroleum	**(I)** Fire in aircraft nose section.
95	05-13-71	Boeing 747	United States	Northwest	**(I)** Fire in No. 3 engine.
96	07-19-71	Boeing 727	United States	United	**(I)** Pilot observed electrical overheat odor; brake valve switch in wrong position.
97	07-21-71	Boeing 707	United States	American	**(I)** No. 3 engine exploded at takeoff; fan separation due to fatigue.
98	07-26-71	Douglas DC-3C	United States	n/a	**(I)** Fire in left engine.
99	08-08-71	Vickers Viscount	United States	Aloha	**(I)** Fire below passenger cabin floor caused by electrical short.
100	10-11-71	Douglas DC-3	United States	Mid America	**(I)** Fire in right engine caused by fuel leak.
101	11-08-71	Boeing 747	United States	Eastern	**(I)** Fire in No. 1 engine following takeoff.
102	12-04-71	Douglas C-47A	Burma	Union of Burma	**(I)** Abandoned takeoff; fumes in cockpit.
103	12-24-71	Lockheed L-188	Peru	LANSA	**(A)** Lightning struck aircraft followed by explosion, crash and fire.
104	01-06-72	Hawker Siddeley HS-748	Mexico	S.A.E.S.A.	**(A)** Possible in-flight fire caused crash.
105	01-11-72	Canadair CL-44	Saudi Arabia	n/a	**(I)** Fire in No. 3 engine; no cause determined.
106	02-16-72	Convair CV-600	United States	Texas International	**(I)** Fire in right engine.
107	03-19-72	Douglas DC-9	United States	Delta	**(I)** Fire in No. 2 engine; failure of compressor disc.
108	03-19-72	Lockheed L-188	United States	Universal	**(I)** No. 2 propeller ruptured fuel tank causing explosion.
109	06-28-72	Gulfstream GII	United States	Linden Flight Service	**(I)** Battery overheat leading to electrical failure and fire.
110	07-21-72	Douglas DC-3	Colombia	Acme Leasing	**(I)** Report of smell of burning and smoke filling cabin.
111	08-04-72	Douglas DC-3	United States	Mercer Enterprises	**(I)** In-flight fire in right engine and nacelle.
112	08-14-72	Ilyushin IL-62	Germany	Interflug	**(A)** Fire in tail.
113	11-03-72	Hawker Siddeley Comet 4C	Libya	Egyptair	**(I)** Fire in No. 2 engine; failure of turbine disc.
114	04-08-73	Boeing 707	Israel	Phoenix Airways	**(I)** Fire in No. 1 engine.
115	05-01-73	Boeing 707	United States	American	**(I)** Explosion of portable oxygen cylinder while administering oxygen to passenger.
116	06-22-73	Douglas DC-7	United States	Skyways International	**(A)** Possible in-flight engine fire or turbulence; loss of control.
117	07-09-73	Douglas DC-10	United States	American	**(I)** Portable oxygen generator ignited while administering oxygen to passenger.
118	07-11-73	Boeing 707	France	Varig	**(A)** Fire in waste-paper bin of right aft toilet.
119	09-05-73	Boeing 727	Vietnam	Air Vietnam	**(I)** Explosion of coffeemaker in front center galley.
120	09-17-73	Douglas DC-6A	United States	Air Haiti	**(I)** Fire in No. 3 engine caused by No. 9 cylinder separation.
121	10-26-73	Curtiss C-46F	Columbia	Aerocosta	**(I)** Fire in left engine, ditched in ocean.
122	11-03-73	Douglas DC-10	United States	National	**(A)** Disintegration of No. 3 engine fan assembly; fragments penetrated fuselage.
123	11-03-73	Boeing 707	United States	Pan Am	**(A)** Smoke in cockpit from hazardous material; loss of control.
124	12-07-73	Curtiss C-46	Bolivia	Transportes Aereos	**(I)** Fire in left engine.
125	02-05-74	Douglas DC-8	Thailand	Japan Air	**(I)** Fire in No. 3 engine.
126	02-06-74	Douglas DC-6	United States	UTA	**(I)** Fire in area of left main landing gear.
127	02-16-74	Boeing 707	United States	TWA	**(I)** Explosion in coffeemaker in No. 3 gallery.
128	02-23-74	Douglas C-47	Colombia	TAL	**(I)** Fire in right engine.
129	03-05-74	Gates Learjet	Bolivia	n/a	**(I)** Fire in No. 2 engine.
130	03-05-74	Nihon Aeroplane YS-11A	United States	n/a	**(I)** Excessive temperatures in turbines of both engines.
131	03-17-74	Boeing 707	United States	TWA	**(I)** Coffeemaker overheated and caused small, in-flight fire.
132	03-26-74	de Havilland Heron	United States	Flightways Aviation	**(I)** Fire in leading edge of wing caused by malfunctioning heating regulator.
133	04-07-74	Lockheed Hercules C-130	United States	Alaska International	**(I)** Disintegration of No. 1 engine and fire in No.1 nacelle.

Event No.	Date (M-D-Y)	Aircraft Type	Location	Operation	Circumstances (A) Accident (I) Incident
134	06-13-74	Douglas DC-3	Puerto Rico	North Cay Airways	**(I)** Fire in No. 1 engine during takeoff climb.
135	11-05-74	Douglas DC-9	United States	Allegheny	**(I)** Electrical fire during approach caused smoke in cabin.
136	12-28-74	Lockheed Lodestar L-18	Guatemala	nonscheduled passenger	**(I)** Fire (no data).
137	02-03-75	Hawker Siddeley HS 748	Philippines	PAL	**(A)** Fire in right engine.
138	06-16-75	Martin 404	United States	Southeast Airlines	**(I)** Fire in accessory section of No. 2 engine.
139	07-15-75	Douglas DC-10	United States	National	**(A)** Fire and body of passenger found in right aft restroom.
140	09-24-75	de Havilland DHC-6	Canada	Imperial Oil	**(I)** Explosion and fire in left engine.
141	11-06-75	Aerospatiale Caravelle	Africa	Air Afrique	**(I)** Fumes in cockpit caused by thermal overload of stand-by battery.
142	11-12-75	Douglas DC-10	United States	Overseas National	**(A)** Disintegration and fire in No. 3 engine caused by ingestion of birds during takeoff.
143	01-22-76	Douglas DC-3	United States	n/a	**(A)** Electric generator failure; in-flight fire.
144	05-20-76	Boeing 727	United States	American Airlines	**(I)** Fire in cabin between seats 21F & 22F, extinguished by crew and passengers, source not determined.
145	06-01-76	Lockheed L-1011	United States	TWA	**(A)** Fire in lower fuselage; vaporizing hydraulic fluid under pressure ignited by arcing electrical wiring.
146	08-04-76	Boeing 707	Tunisia	BMA	**(I)** No. 4 engine failure; fire during takeoff.
147	08-06-76	North American TB-25	United States	Air Chicago	**(A)** Engine failure, fire; attempted emergency landing.
148	09-07-76	Douglas DC-3	Canada	nonscheduled	**(A)** Lavatory fire, emergency landing.
149	10-06-76	Douglas DC-8	Barbados	Cubana	**(A)** Detonation of explosive device; fire.
150	10-13-76	Aerospatiale Caravelle	India	IAC	**(A)** Engine failure on takeoff; fuel fire; attempted emergency landing.
151	02-09-77	Canadair	Hong Kong	TransAmer Cargo	**(A)** Internal engine fire on takeoff, engine fell off; crashed.
152	08-09-77	Gates Learjet 25	United States	Champion Home	**(A)** In-flight explosion; fuel/battery suspected.
153	06-10-77	Douglas DC-6	Bolivia	commercial operation	**(A)** Engine fire in flight, improper maintenance.
154	03-11-77	Curtiss C-46	Virgin Islands	freight	**(I)** Engine fire in flight , fuel leak from carburetor.
155	02-12-78	Fokker F27	France	Air Inter	**(I)** Smoke on flight deck, water in electric console.
156	03-11-78	Lockheed Electra L-188C	United States	TIA	**(A)** Tire explosion, engine fire in flight.
157	03-21-78	Convair CV-340	United States	private	**(A)** In-flight fire, right engine, emergency landing.
158	03-23-78	Douglas DC-3	Grand Turk Island	Dominica Air Service	**(A)** Crashed at sea; fire and smoke of undetermined origin reported before crash.
159	04-16-78	Boeing 747	United States	British Airways	**(I)** In-flight fire, No. 4 engine/gear box failure.
160	05-21-78	Boeing 727	United States	American Airlines	**(I)** In-flight failure, No. 1 engine turbine, fire.
161	09-24-78	Gulfstream	United States	private	**(A)** Engine shut down, forced landing, torching exhaust pipe.
162	10-01-78	Douglas DC-9	Japan	scheduled passenger	**(I)** Fire in flight in aft lavatory; passenger deliberately set fire with liquid propane gas (LPG).
163	03-29-79	Fokker F27	Canada	Quebec Air	**(A)** Engine explosion; fire in flight, crashed during emergency landing attempt.
164	05-17-79	Douglas DC-4	Gulf of Mexico	n/a	**(A)** Fire of undetermined origin in flight, no passengers on board, aircraft ditched, three crew survived.
165	06-01-79	Douglas DC-4	Canada	n/a	**(A)** No. 1 engine fire after takeoff; landed with engine burning.
166	06-11-79	Douglas DC-3	United States	n/a	**(A)** Engine fire, engine separated from aircraft.
167	06-14-79	Douglas DC-4	United States	n/a	**(A)** Reported fire on flight deck; emergency landing on lake.
168	08-13-79	Consolidated Catalina	Canada	commercial operation	**(A)** Fire in right engine, returning from fire-suppression flight.
169	08-26-79	Fokker F28	Sweden	Linjeflyg	**(I)** Engine fire caused by improper electrical wiring, short circuit and fuel leaks.
170	11-24-79	Convair CV-580	Bahamas	Mackey International	**(A)** Fire in right wheel well; engine separated in flight.
171	11-26-79	Boeing 707	Saudi Arabia	Pakistan International	**(A)** Fire in aft cabin area, flight crew incapacitated; crashed and exploded.
172	02-15-80	Convair CV-240	Haiti	private	**(A)** Left engine and wing on fire.
173	04-7-80	Grumman Mallard	Virgin Islands	Antilles Airboats	**(I)** Fire in engine-mount electrical junction box.
174	04-28-80	Douglas DC-4	Bolivia	nonscheduled freight	**(A)** Engine carburetor failure, fuel fire in flight.
175	05-17-80	Consolidated Catalina	United States	private	**(I)** Smoke and fire in two main engines.
176	05-24-80	Convair CV-240	United States	n/a	**(A)** Aircraft took off with right engine on fire.
177	06-22-80	Lockheed L-1049H	United States	Air Traders International	**(A)** No. 2 engine fire warning, crashed shortly after takeoff, destroyed by ground fire.
178	07-05-80	Fairchild Packet	United States	nonscheduled freight	**(A)** No. 1 engine fire warning during landing, left wing tip exploded.

Event No.	Date (M-D-Y)	Aircraft Type	Location	Operation	Circumstances (A) Accident (I) Incident
179	08-19-80	Lockheed L-1011	Saudi Arabia	Saudi Arabian Air	**(A)** Uncontrolled fire in C-3 cargo compartment; aircraft destroyed after landing; no survivors.
180	09-02-80	Israel Aircraft Industries IAI Westwind 1124	United States	corporate	**(I)** Electrical fire in coffeemaker.
181	10-20-80	Boeing 727	Germany	TAP Air Portugal	**(I)** Engine failure and fire during takeoff.
182	12-21-80	Aerospatiale Caravelle	Colombia	Colombian Airlines	**(A)** Explosion and fire after takeoff; crashed; first flight after extensive maintenance.
183	02-02-81	Boeing 737	Saudi Arabia	Saudi Arabian	**(A)** No. 1 engine fire warning, emergency landing.
184	03-28-81	Douglas DC-4	Virgin Islands	Tuky Air Transport	**(A)** Fire in No. 3 engine while en route.
185	03-29-81	Boeing 707	Belgium	Sobelair	**(A)** Uncontained failure and fire in No. 3 engine; emergency landing.
186	04-10-81	Lockheed L-1011	India	Saudi Arabian Airline	**(I)** Fire after takeoff; believed the result of improperly handled oxygen cannister.
187	06-27-81	Fairchild Packet	United States	commercial operation	**(A)** Fire and explosion in right engine.
188	07-14-81	Douglas DC-4	United States	commercial operation	**(A)** Cylinder failure in right engine, engine fire; engine and partial wing separation in flight.
189	08-27-81	Fairchild Packet	United States	commercial operation	**(A)** Fire and failure in right engine. Emergency landing. [Same aircraft as Event No. 187.]
190	11-12-81	Tupolev TU-154	Yemen	Aeroflot	**(I)** Engine fire; emergency landing and evacuation.
191	01-17-82	Convair CV-440	United States	Island Airlines	**(A)** Fire in right engine; aircraft ditched after engine failure.
192	02-21-82	de Havilland DHC-6	United States	Pilgrim Airlines	**(A)** Deicing alcohol leak in flight; ignition and fire; emergency landing.
193	09-09-82	Fairchild FH-227	Bahamas	Autec	**(A)** Explosion and fire in left engine; emergency evacuation.
194	11-04-82	Tupolev TU-134	Poland	Aeroflot	**(A)** Fire under right wing; emergency landing.
195	11-12-82	Swearingen SA Metro II	Denmark	Scandinavian Air Taxi	**(A)** Electrical short/fire; 70 PSI oxygen leak left-side cockpit console.
196	12-24-82	Ilushyn IL-18	China	CAAC-China	**(A)** Fire and toxic smoke in cabin; fire started by a passenger's cigarette.
197	06-02-83	Douglas DC-9	United States	Air Canada	**(A)** Smoke and fire in aft lavatory; emergency landing; officially undetermined cause; most likely electrical origin.
198	06-06-83	Fairchild Packet	Taiwan		**(A)** Engine fire reported after takeoff; crashed into sea.
199	06-24-83	Douglas DC-3	United States	scheduled passenger	**(A)** Fire in left engine.
200	08-27-83	Swearingen	United States	scheduled passenger	**(A)** Fire and smoke in cockpit and cabin; arcing wires and leaking oxygen system involved.
201	05-06-84	Curtiss C-46	Colombia	Samuel Selum Arce	**(A)** Fire in No. 1 engine after takeoff.
202	06-02-84	Boeing 747	Thailand	Air India	**(A)** Fire in No. 4 engine; unable to extinguish; emergency landing.
203	06-05-84	Boeing 720	United States	nonscheduled passenger	**(I)** Uncontained No. 3 engine failure; 7th stage turbine failure/fire.
204	11-18-84	Boeing 747	United States	National Airlines	**(I)** No. 3 engine failure at rotation, fire, secondary damage to No. 4 engine.
205	12-20-84	de Havilland DHC-6	Tanzania	training	**(A)** Fire in right engine during approach; crashed.
206	03-07-85	Douglas B-26 Invader	United States	private	**(A)** Fire in left engine during ferry flight.
207	05-11-85	Boeing 737-200	Qatar	Saudi Arabian Airlines	**(I)** Second stage turbine disk ruptured in No. 2 engine/uncontained; fire.
208	06-10-85	Gates Learjet 24B	France	Euralair International	**(A)** Uncontrolled descent into ground; some in-flight fire evidence; crew incapacitation suspected.
209	08-09-85	Boeing 747	United Arab Emirates	private	**(I)** Fire in No. 4 engine 16 minutes after takeoff.
210	08-22-85	Boeing 737	England	British Air Lines	**(A)** Uncontained engine failure, left engine, aircraft destroyed by fire.
211	10-18-85	Lockheed L-1011	Philippines	Royal Jordanian	**(I)** Fire below floor, behind wall lining aft of L-3 door; electrical.
212	12-31-85	Douglas DC-3	United States	private	**(A)** Fire and smoke below cabin floor; cabin heater, fuel/electrical involvement suspected.
213	3-26-86	Douglas DC-3	United States	scheduled freight	**(A)** No. 2 engine failure and fire, emergency landing.
214	7-02-86	Tupolev TU-134A	U.S.S.R.	Aeroflot	**(A)** Baggage fire in rear baggage compartment; flammable substance in baggage; emergency landing.
215	08-04-86	Grumman Avenger	United States	private	**(A)** Engine fire during ferry flight; crashed inverted.
216	12-23-86	Douglas DC-4	Pacific Ocean	training flight	**(A)** Pilot reported uncontrollable fire in No. 3 engine; ditched in ocean near Washington, U.S.
217	03-25-87	Douglas DC-10	United States	American Airlines	**(I)** Smoke in cabin caused by faulty auxiliary power unit; passengers injured during evacuation.
218	04-23-87	Swearingen Metro II	United States	scheduled freight	**(A)** Uncontained turbine failure, fire right engine, loss of electrical power; crashed.

Event No.	Date (M-D-Y)	Aircraft Type	Location	Operation	Circumstances (A) Accident (I) Incident
219	06-19-87	de Havilland DHC-8	United States	scheduled passenger	**(I)** Explosion and fire in right engine, engine fuel return line ruptured.
220	09-05-87	Ilushyn IL-62	Poland	LOT Polish Airlines	**(A)** Uncontained No. 2 engine failure; crashed during emergency landing attempt.
221	08-16-87	Boeing 767	Germany	American	**(I)** Oil filter caution and fire warning on No. 2 engine during initial climb.
222	11-28-87	Boeing 747	Near Mauritius	South African Airways	**(A)** Fire in front pallet in main-deck cargo hold; crashed at sea; no survivors.
223	12-05-87	Hawker Siddeley HS-125	United States	Scott Cable Communications	**(A)** In-flight fire, No. 2 engine at FL370; cracked exhaust cone; crashed during approach.
224	12-21-87	Douglas DC-6	Costa Rica	Aeronica	**(A)** Explosion and separation of No. 3 engine; fire in No. 4 engine.
225	01-18-88	Ilushyn IL-18	China	CAAC-China	**(A)** No. 4 starter/generator overheat, caused oil line rupture, fire, loss of control and crash.
226	02-03-88	McDonnell Douglas MD-83	United States	American	**(I)** Hydrogen peroxide/sodium orthosilicate cargo ignited in flight; crew unaware of hazardous materials.
227	04-12-88	Douglas DC-3	South Africa	United Air	**(A)** Pilot reported fire on board, attempted return to airport; crashed.
228	04-15-88	de Havilland DHC-8	United States	Horizon Air	**(A)** Major fire in right engine; precautionary landing; 4 passengers injured.
229	07-06-88	Canadair CL-44	Colombia	Lineas Aereas	**(A)** Uncontained failure No. 4 engine, fire; attempted to return, lost control and crashed.
230	07-27-88	Swearingen Metro III	United States	Peninsula Airways	**(I)** Tire explosion and brake fire in left wheel well.
231	08-02-88	Yakolev YAK-40	Bulgaria	Balkan Bulgarian Airlines	**(A)** Crashed shortly after takeoff after reported in-flight fire.
232	12-23-88	Curtiss C-46	Puerto Rico	Haiti Air Freight	**(A)** Engine fire; overran runway during attempt to return.
233	01-08-89	Boeing 737	United Kingdom	British Midland	**(A)** No. 1 engine failure, improperly shut-down No. 1 engine; crashed; severe post-crash fire.
234	02-02-89	Douglas DC-9	Norway	scheduled passenger	**(I)** Explosion/smoke/fire in flight deck circuit breaker panel; unscheduled landing.
235	04-08-89	Lockheed Hercules C-130	Angola	Transafrik	**(A)** Forced landing; fire in both engines; possibly the result of hostile small-arms fire.
236	04-10-89	Beech BE-200	United States	Southern Corp.	**(A)** In-flight fire; hydrochloric and sulfuric acid traces found on passenger articles.
237	05-05-89	Boeing 747	Hong Kong	Lufthansa	**(I)** Fire warning in aft cargo compartment; burned cargo found in compartment.
238	05-21-89	Douglas DC-3	Canada	Central Mountain Air	**(A)** Fire in right engine; unable to extinguish, spread to fuel tanks on landing.
239	07-20-89	Curtiss C-46	Bolivia	Aerominas	**(A)** Power loss in left engine; smoke in cockpit; fire engulfed aircraft after landing.
240	12-17-89	Fokker F100	Denmark	Air Europe	**(I)** Smoke from flight-deck electrical panel; possible loose generator contactors/terminals.
241	12-30-89	Boeing 737	United States	America West	**(A)** Electrical short in hydraulic pump wiring; fire and emergency landing.
242	01-13-90	Tupolev TU-134	U.S.S.R.	Aeroflot	**(A)** Crew reported fire on board, initiated emergency descent; crashed.
243	02-24-90	Fokker F27	Germany	FTG Air Service	**(A)** One engine on fire and separated from aircraft; second engine also on fire; emergency landing.
244	04-05-90	Lockheed L-1049	Puerto Rico	AMSA	**(A)** Multiple engine failures and fires; ditched off shoreline.
245	04-26-90	Douglas DC-3	Philippines	Manila Aero Transport	**(A)** Engine fire and forced landing.
246	05-11-90	Boeing 737	Philippines	Philippine Airlines	**(A)** Fuel tank fire/explosion while being towed on ground. Cause unknown.
247	11-17-90	Tupolev TU-154	Czechoslovakia	Aeroflot	**(A)** Freighter caught fire in flight; emergency landing off airport.
248	05-15-91	Douglas DC-3	Colombia	Aerolinas del Este	**(A)** Engine fire after takeoff; crashed during emergency landing.
249	07-11-91	Douglas DC-8	Saudi Arabia	Nationair	**(A)** Tire failure and wheel well fire on takeoff; crashed short of runway while returning.
250	10-25-91	Hawker (?)	Canada	Air Quebec	**(A)** Engine fire in flight; aircraft destroyed by fire after landing.

Publications Received at FSF Jerry Lederer Aviation Safety Library

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Reference Materials

Advisory Circular 23-11, 12/2/92, Type Certification of Very Light Airplanes with Power-plants and Propellers Certificated to Parts 33 and 35 of the U.S. Federal Aviation Regulations (FAR). Washington, D.C. U.S. Federal Aviation Administration (FAA), 1992. 170 p.; ill.

Purpose: This advisory circular (AC) describes one acceptable means of compliance with Part 23 of the FAR for type certification of certain small airplanes. This material is neither mandatory nor regulatory, and is for guidance purposes. Because the method of compliance in this AC is not mandatory, the terms "shall" and "must" apply only to an applicant who chooses to adhere to this particular method. The applicant may elect to follow an alternative method, provided the alternative method is also found acceptable by the FAA. Lengthy appendices include an overview of aircraft type certification, a comparison of the FAR and the corresponding Joint Aviation Requirements (JAR) for Very Light Aeroplanes (VLA) as well as the April 26, 1990, text of the JAR-VLA.

Advisory Circular 23.701-1, 11/13/92, Flap Interconnections in Part 23 Airplanes. Washington, D.C. U.S. Federal Aviation Administration, 1992. 4 p.

Purpose: This advisory circular (AC) provides information and guidance concerning an acceptable means, but not the only means, of showing compliance with the requirements of AC No. 23.701 (Amendment 23-42) of the Federal Aviation Regulation (FAR) applicable to flap interconnections. This material is neither mandatory nor regulatory in nature.

SAE Dictionary of Aerospace Engineering. William H. Cubberly, ed. Warrendale, Penn.: Society of Automotive Engineers Inc., 1992. 845 p.

<u>Keywords</u>
1. Aeronautics — Dictionaries.
2. Astronautics — Dictionaries.
3. Society of Automotive Engineers.

Description: This technical dictionary contains nearly 20,000 terms edited for the aerospace and aeronautical engineers who design, test and manufacture aerospace vehicles, components and parts. Each entry is suited for students and writers in the field of aerospace technology. Highlights include 5,188 terms from SAE aerospace standards and reports, denoted by the bracketed standard or report number, and 4,038 terms from the U.S. National Aeronautics and Space Administration (NASA) Thesaurus. Also, 9,541 general engineering and data processing terms are included.

Reports

A Review of Civil Aviation Propeller-to-person Accidents, 1980-89 / William E. Collins. Washington, D.C. U.S. Federal Aviation Administration, 1993. 7p. Civil Aeromedical Institute. Available through the National Technical Information Service.*

<u>Keywords</u>

1. Propellers, Aerial — Safety.
2. Rotors (Helicopters).
3. Aeronautics — United States Accidents.
4. Propeller Accidents.

Summary: This study was undertaken to provide information regarding the circumstances surrounding recent accidents to pilots, passengers or ground crew that occur from contact with a rotating propeller blade and compare those findings with the frequency and circumstances of propeller accidents during the 1965-1979 period.

The U.S. National Transportation Safety Board (NTSB) provided computer retrievals of brief reports of all propeller and rotor accidents during the period from 1980 through 1989. These reports were examined and analyzed by type of accident, degree of injury, actions of pilots, actions of passengers and ground crew, night or day, and other conditions. The computer search revealed a total of 104 reports of "propeller-to-person" accidents involving 106 persons. According to the report, those persons at most risk for a propeller-to-person accident are deplaning passengers and passengers attempting to assist the pilot prior to takeoff and after landing. The accident frequency for the 1980-1989 period was lower than that reported for the 1960s and 1970s.

Recent declines are attributed to a combination of FAA educational efforts, economic conditions and changes in the types of aircraft used by pilots. [Modified Abstract]

Aviation Safety: Slow Progress in Making Aircraft Cabin Interiors Fireproof: Report to Congressional Requesters/U.S. General Accounting Office (GAO). Washington, D.C.: General Accounting Office**, 1993. 33 p.; ill. Includes bibliographical references.

Keywords
1. United States — Federal Aviation Administration.
2. Aircraft Cabins — Safety Regulations — United States.
3. Airplanes — Fires and Fire Prevention — Law and Legislation — United States.

Summary: This report provides general information on the FAA's latest flammability standards for materials used in aircraft cabins. Specifically, GAO was asked to provide information on the proportion of the U.S. aircraft fleet that meets or is expected to meet the FAA's latest flammability standards through 1999; the estimated cost if all aircraft had to meet the standards by certain hypothetical dates; and the estimated safety benefit of meeting the standards under each hypothetical date.

Flammability standards for interior cabin materials were upgraded in 1986 and 1988 to increase the likelihood that occupants would survive a post-crash fire and the resulting smoke and toxic gases. The FAA issued these new standards after fire tests demonstrated that stricter standards could provide up to 17 additional seconds to allow occupants to escape a burning aircraft. These standards applied to all aircraft manufactured after August 19, 1990.

The report estimates that 75 lives and US$80 million could potentially be saved if the entire U.S. aircraft fleet complied by 1999. In establishing stricter flammability standards, the FAA anticipated that almost 85 percent of the fleet would comply by the year 2000 and indicated that it would consider proposing a mandatory retrofit requirement if all airlines did not meet the standards as anticipated.

The report further stated that although a number of newly manufactured aircraft are meeting the flammability standards, no airline has replaced or plans to replace the interior components of in-service aircraft. As a result, 45 percent of the aircraft fleet is expected to be operating with cabin interiors not meeting the latest flammability standards by the end of the decade.

In view of the safety benefits of modifying aircraft, possibly saving 75 to 100 lives through 2018, the GAO recommends that the secretary of transportation direct the FAA administrator to reassess whether to issue a regulatory requirement mandating a specific date for all aircraft in the fleet to comply with the latest flammability standards for cabin interiors.

The report includes FAA comments on the GAO findings. In short, the FAA's deputy director and other DOT officials do not believe that a reassessment of the flammability standards is warranted; a cost analysis for replacing cabin interiors shows that the cost to retrofit the fleet outweighs the potential safety benefits.

Books

Tex Johnston: Jet-age Test Pilot / by A.M. "Tex" Johnston with Charles Barton. Washington, D.C.: Smithsonian Institution Press, 1991. 274 p.; ill.; Includes index.

Keywords
1. Johnston, A. M. (Alvin M.)
2. Test pilots — United States — Biography.

Summary: Alvin M. "Tex" Johnston's autobiography illustrates the career of one of America's most daring and accomplished test pilots. Tex Johnston flew the first U.S. jet airplanes and, in a career spanning the 1930s through the 1970s, helped create the jet age at such pioneering aerospace companies as Bell Aircraft and Boeing.

From his early career as an aerobatic pilot for a flying circus to his aviation breakthough test flights for Boeing, his flights were often landmarks [including the XB-47, the first six-jet-engine bomber, the XB-52 and a barrel roll of a Boeing 707]. As a developmental pilot, Johnston followed an aircraft from conception to sales, working with engineers and designers, and testing the limits of prototypes. Johnston represents an era when aviation firsts were collaborative and the work of engineers and designers was verified not by computer but by the skill and daring of test pilots.

The Universal Man: Theodore von Karman's Life in Aeronautics / Michael H. Gorn. Washington, D.C.: Smithsonian Institution Press, 1992. 202 p., 32 p. of plates; ill. Smithsonian history of aviation series. Includes bibliographical references and index.

Keywords
1. Von Karman, Theodore, 1881-1963.
2. Aeronautical engineers — United States — Biography.

Summary: Theodore von Karman's contributions span many decades of evolution in aeronautical theory and revolution in aviation practice. He pioneered the use of applied mathematics in aeronautics and astronautics, discovered some of the fundamental laws of aerodynamics and applied these to designing aircraft, dirigibles, rockets and missiles. As a pioneer in aerospace engineering, von Karman demonstrated the first solid-propellant rocket engine.

Considered the moving force behind many now-famous institutions, including NASA's Jet Propulsion Laboratory, California Institute of Technology's Guggenheim Aeronautical Laboratory and the U.S. Air Force Scientific Advisory Board, von Karman received the first National Medal of Science in 1963 from U.S. President John Kennedy. This compact, non-technical work provides a rounded picture of this warm and humane scientist's life and examines the extent to which personality influences the course of science.

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Accident/Incident Briefs

This information is intended to provide an awareness of problem areas through which such occurrences may be prevented in the future. Accident/incident briefs are based on preliminary information from government agencies, aviation organizations, press information and other sources. This information may not be entirely accurate.

Air Carrier

Hard Landing Follows Tardy Autopilot Disengagement

Airbus A-310. Substantial damage. No injuries.

The Category I landing at an African airport was executed with the airplane in autopilot mode. The crew elected to maintain autopilot control below decision height.

Six seconds before touchdown, at an altitude of 96 feet (28.8 meters), the flight crew assumed manual control. The airplane immediately lost its correct landing configuration and touched down at an angle nearly 16 degrees off runway alignment and to the left of the runway centerline. The left main gear was off the pavement for a distance of 894.3 feet (271 meters). The left main gear and the aft fuselage received substantial damage.

An investigation determined that the flight crew was not trained for autolands and had descended the airplane below company minima with the autopilot engaged.

Overweight Baggage Forces Aborted Takeoff

Tupolev 154. Aircraft destroyed. No serious injuries.

The airplane was operating as a charter flight when it overran the runway following an aborted takeoff at a Russian airport.

The Tupolev was carrying 62 passengers and a crew of five at the time of the accident.

An investigation determined that during the takeoff roll, the aircraft would not rotate and that the aborted takeoff was executed at a speed of 170 knots. The aircraft's center of gravity was found to be significantly forward of its limit, and the Tupolev was well above its maximum takeoff weight. The actual weight of baggage was 16.5 tons (14.85 metric tons) although only 10 tons (9 metric tons) had been declared.

Cockpit Confusion Results in Gear-up Landing

Boeing 707. Aircraft destroyed. No injuries.

During a test flight, the aircraft landed with its landing gear up after a planned go-around.

The flight crew intended to leave the gear down after the go-around while a second approach was initiated, but confusion in the cockpit caused the copilot to retract the gear just before the aircraft touched down.

There were no serious injuries, but the aircraft sustained substantial fuselage and engine damage during the ground slide.

Attempts to recover the 707 were unsuccessful and the aircraft was finally cut into sections and removed from the runway.

Sightseeing Flight Ends on Foggy Hillside

McDonnell Douglas DC-3. Aircraft destroyed. Twenty-eight fatalities. Four serious injuries.

The DC-3 was on a daylight sightseeing tour when weather conditions deteriorated.

The aircraft was inadvertently flown into an area of hills covered by low clouds. A subsequent investigation determined that the DC-3 impacted a tree-covered hill in fog while in a left turn. Twenty-five passengers and three crew members were killed.

Convair Hits Trees at Site Mistaken for Airport

Convair 640. Aircraft destroyed. Thirty fatalities. Twenty-six serious injuries.

The twin-engine turboprop aircraft began its descent from 7,000 feet (2,100 meters) in moonless night visual meteorological conditions with reported visibility of 4.96 miles (8 kilometers).

While descending, the pilot reported downwind and began landing preparations although he was still 28 nautical miles from the destination airport. The aircraft struck trees while on short final for a site the pilot had mistaken for the airport. The left wing tip broke off when it hit the trees. The pilot tried to pull up, but the aircraft struck the ground before he could recover. Twenty-six passengers and four crew members were killed in the crash. The aircraft was destroyed.

Sloppy Maintenance Cripples Dornier

Dornier 228-200. Substantial damage. No injuries.

About 15 minutes after takeoff, at an altitude of 9,000 feet (2,700 meters), the pilot suddenly had difficulty controlling the aircraft directionally.

A few seconds later, there was a bang followed by a strong left yaw. The rudder pedals were immovable but the pilot compensated for the yaw by throttling down the right engine and adopting a 20-degree right bank. The pilot was able to maneuver the turboprop aircraft back to the airport, where he landed the aircraft safely.

A subsequent inquiry revealed that all the fabric (carbon- or glass-reinforced plastic) from the rudder was torn off, and the upper part of the rudder was bent to the right. During maintenance a short time before the flight, the rudder and elevators had been freshly covered in a painter's shop. The work was neither performed nor documented in an approved manner. The investigation concluded that the material on the rudder was lost because recovering had not been performed according to the manufacturer's directives, thereby reducing the adhesiveness of the glue.

Wind Shear, Fog Shorten Approach

Cessna 340. Aircraft destroyed. Five serious injuries.

At the time of the Cessna's arrival, weather conditions were reported as erratic, with winds and precipitation levels changing minute-to-minute.

During an instrument landing system (ILS) approach, the aircraft collided with trees and crashed two miles short of the runway. The pilot reported later that he could not remember the accident, but recalled receiving a wind-shear alert and that rain was falling heavily. He also reported an intermittent problem with the autopilot heading mode. Fog and low ceilings were also present when the accident occurred.

Scud Running Downs Duke

Beech 60 Duke. Aircraft destroyed. One fatality.

The aircraft was flying low at night in heavy rain when it struck the ground at a high speed while operating under visual flight rules. Impact occurred with a 15-degree descent angle and a 50-degree left bank.

An investigation determined that the flaps and landing gear were fully extended. The wings and the tail were destroyed when the aircraft struck trees. The engines were torn away during ground impact and the wreckage was consumed by a post-crash fire.

The crash inquiry concluded that the pilot had not obtained a complete weather briefing about rapidly changing frontal conditions. His decision to press on until losing visual cues rather than electing to change to instrument flight rules was a significant contributing factor, the inquiry said. It said cockpit-task overload and vertigo likely caused the pilot to lose control of the aircraft.

Fuel Exhaustion Leads to Predictable Outcome

Cessna 414. Aircraft destroyed. One fatality.

During daylight cruising, the Cessna's left engine quit because of fuel exhaustion. The second engine quit during an emergency descent.

The aircraft had been diverted and vectored for an instrument landing system (ILS) approach just prior to the engine failures. The 414 struck a hill. A subsequent investigation determined that the fuel tanks were completely empty. Investigators said the pilot's failure to properly alert controllers to his emergency situation contributed to the crash.

Training Flight Kills Two

Beech 55 Baron. Aircraft destroyed. Two fatalities.

The twin-engine aircraft was observed at low altitude, in a climb, with the landing gear extended on a daylight dual training flight. The Beech then suddenly rolled inverted, returned to an upright attitude and collided with the ground. A post-crash inquiry determined that the left propeller was feathered. No failure was found. The inquiry concluded that the instructor pilot failed to properly supervise the practice of simulated emergency procedures.

Engine-failure Practice Ends Abruptly

Piper PA28. Substantial damage. One serious injury.

A simulated engine failure was attempted in the single-engine aircraft shortly after takeoff. However, the student pilot elected not to continue straight ahead and turned left toward a clear landing area.

The instructor took control and attempted a go-around. The aircraft struck the ground under full power, seriously injuring the instructor.

Glider-tug Flight Ends in Tragedy

D62 Condor. Aircraft destroyed. One fatality.

The tug aircraft took off with a glider in tow and was climbing normally when, at an altitude of 200 feet (60 meters), the engine sputtered and then stopped.

The glider was released, and the tug aircraft banked to the left and crashed. The tug pilot was killed. The glider landed safely.

An investigation did not find any conclusive evidence of an engine malfunction. The inquiry concluded that while positioning for a forced landing (following partial or total engine failure), the pilot misjudged his height and bank angle and the right wing tip struck the ground. The tug pilot had logged a total of 329 flying hours, of which one hour was in type

Rotorcraft

Weather Shortens Cross-country Trip

Bell 206B. Aircraft destroyed. One fatality.

The pilot had taken off from a private helipad for a cross-country flight. The helicopter collided with trees and a condominium complex a mile north of the departure point.

The pilot, the sole occupant of the aircraft, was killed and the aircraft was destroyed. Instrument meteorological conditions prevailed at the crash site.

Clean-up Maneuver Bags Bell

Bell 206. Substantial damage. No injuries.

The helicopter was maneuvering about 10 feet (3 meters) above the ground when it fell and collided with terrain.

The pilot told accident investigators that he was maneuvering close to a farm-field water-sprinkler system to wash the helicopter when the engine ingested water and flamed out. The certificated commercial pilot was not injured.

Sling Load Destroys Hughes

Hughes 369D. Aircraft destroyed. One fatality.

The helicopter was carrying a sling load, which was not weighted, between two drill sites when it came apart in the air.

The pilot, the sole occupant of the helicopter, was killed. ♦