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"The Hindenburg" redirects here. For the film, see The Hindenburg (film); for other uses, see Hindenburg.

LZ 129 Hindenburg

Hindenburg at Lakehurst Naval Air Station

Career

Nationality
Designer
Ludwig Dürr
Manufacturer
Luftschiffbau Zeppelin
Manufactured
1936
Maiden flight
4 March 1936
Fate
6 May 1937 caught fire and exploded while mooring

General characteristics

Crew
40 to 61
Passengers
50
Length
245 metres (800 ft)
Diameter
41 metres (130 ft)
Gas type
Hydrogen
Gas capacity
200,000 cubic metres (7,100,000 cu ft)
Disposable lift
112 metric tonnes
Power plant
4 Daimler-Benz diesel engines, each 1,200 horsepower (890 kW)
Max speed
135 kilometres per hour (84 mph)

LZ 129 Hindenburg was a German rigid passenger "Zeppelin" airship. Along with its sister-ship LZ 130 Graf Zeppelin II, it was the largest rigid aircraft ever built. During its second year of service, it went up in flames and was destroyed while landing at Lakehurst Naval Air Station in Manchester Township, New Jersey, U.S., on 6 May 1937. Thirty-six people died in the accident, which was widely reported by film, photography and radio media.

The Hindenburg was named after the late Paul von Hindenburg (1847-1934), President of Germany (1925–1934).
Design and construction

The Hindenburg was built by Luftschiffbau Zeppelin between 1931 and 1936 to a new, all-duralumin design. The man who headed the design team was Doctor Ludwig Dürr, who had headed the design of all Zeppelins except LZ-1 (on which he was a crew member), under the overall direction of Hugo Eckener, the head of the company. It was 245 m (804 ft) long and 41 m (135 ft) in diameter, longer than three Boeing 747s end-to-end, longer than four Goodyear Blimps end-to-end, and only 24 m (79 ft) shorter than the Titanic. It was originally equipped with cabins for 50 passengers and a crew complement of 40, though on the last flight there were an additional 21 crew members in training.

Though construction began in 1931, it was suddenly stopped when the Zeppelin Company went bankrupt. This led Eckener to make a deal with the Nazi Party. He needed money to build the airship, but in return he was forced to display the swastikas on the tail fins. Construction then resumed in 1935.

The Hindenburg was originally intended to be filled with helium, a gas which is heavier than hydrogen but which is not flammable. Most of the world's supply of helium comes from underground fields in the United States, but the United States had imposed a military embargo on helium against Germany. Eckener expected this ban to be lifted and modified the design to have double gas cells (an inner hydrogen cell protected by an outer helium cell). The ban remained, leading the Germans to modify the design of the airship to use only hydrogen as the lift gas, despite the fact that hydrogen, unlike helium, is extremely flammable. It contained 200,000 m³ (7,000,000 ft³) of gas in 16 bags or cells, with a useful lift of 1.099 MN (247,100 pounds).

The Germans had extensive experience with hydrogen as a lifting gas. Hydrogen-related fire accidents had never occurred on civilian Zeppelins, so the switch from helium to hydrogen did not cause much alarm. Hydrogen also gave the craft about 8% more lift capacity.

Four reversible 890 kW (1,200 hp) Daimler-Benz diesel engines gave the airship a maximum speed of 135 km/h (84 mph).

The duralumin frame was covered by cotton cloth varnished with iron oxide and cellulose acetate butyrate impregnated with aluminium powder. The aluminium was added to reflect both ultraviolet, which damaged the fabric, and infrared light, which caused heating of the gas. This was an innovation with the LZ-126 which was operated by the US Navy from 1924 on. The LZ-130 fabric coating was changed to include bronze powder which is less flammable.

It officially made its first flight on 4 March 1936, though several test flights were made the previous year. The cost of a ticket from Germany to Lakehurst was US$400 (about US$5900 in 2008 dollars), which was quite a considerable sum for the Depression era. Hindenburg passengers were generally affluent, including many leaders of industry.
To reduce drag, the passenger rooms were contained entirely within the hull, rather than in the gondola as on the Graf Zeppelin. The interior furnishings of the Hindenburg were designed by Professor Fritz August Breuhaus, whose design experience included Pullman coaches, ocean liners, and warships of the German Navy. The upper A Deck contained small passenger quarters in the middle flanked by large public rooms: a dining room to port as well as a lounge and writing room to starboard. Paintings on the walls of the dining room portrayed the Graf Zeppelin's trips to South America. A stylized world map covered the wall of the lounge. Long slanted windows ran the length of both decks. The passengers were expected to spend most of their time in the public areas rather than their cramped cabins.

The lower B Deck contained washrooms, a mess hall for the crew, and a smoking lounge. Recalled Harold G. Dick, an American representative from the Goodyear Zeppelin Corporation, “The only entrance to the smoking room, which was pressurized to prevent the admission of any leaking hydrogen, was via the bar, which had a swivelling air-lock door, and all departing passengers were scrutinized by the bar steward to make sure they were not carrying out a lighted cigarette or pipe.”

First year of service

During its first year of commercial operation in 1936, the Hindenburg flew 308,323 km (191,583 miles) carrying 2,798 passengers and 160 tons of freight and mail. It made 17 round trips across the Atlantic Ocean, with 10 trips to the U.S. and seven to Brazil. In July 1936, the Hindenburg also completed a record Atlantic double crossing in five days, 19 hours and 51 minutes. After defeating Max Schmeling, the German boxer returned home on the Hindenburg to a hero's welcome in Frankfurt.

On 1 August, the Hindenburg was present at the opening ceremonies of the 1936 Summer Olympics in Berlin. Moments before the arrival of Adolf Hitler, the airship crossed over the Olympic stadium, trailing the Olympic flag from its gondola.

During its first year of service, the airship had a special aluminium Blüthner grand piano placed on board in the music salon. It was the first piano ever placed in flight and helped host the first radio broadcast “air concert.” The piano was removed after the first year to save weight.

The Hindenburg's success encouraged the Luftschiffbau Zeppelin Company to plan the expansion of its airship fleet and transatlantic services. The Hindenburg was used by the Nazis to drop flags in different locations and leaflets expressing Hitler support.

During the winter of 1936–37, several changes were made. The greater lift capacity allowed 10 passenger cabins to be added, nine with two beds and one with four beds, increasing the total passenger capacity to 72.

A 1936 photograph (above) shows the Nazi swastika, as do the well-known disaster images of 1937; film footage over New York City labelled as 1937 also shows shows the swastika, possibly because the swastika did not have the negative meaning it would obtain after the end of the WW2, although the swastika is removed in most web sites by photo editing because of unknown reasons.

Last flight

On the night of 6 May 1937, the Hindenburg left Frankfurt for Lakehurst. This was the first transatlantic trip of the 1937 season.

The crossing was uneventful, except for strong headwinds. The airship was half full, with 36 passengers and 61 crew members (including 21 training crew members), but the return flight was fully booked by people attending the coronation of King George VI, which would take place on 12 May, at Westminster Abbey, London.

The low number of passengers was probably because of concerns of a bomb on board. A letter was sent to the German Ambassador predicting that the airship would be destroyed by a bomb after flying over New York City. The airship arrived in the United States. The airship was already late, and the landing was further delayed because of bad weather. Captain Max Pruss took passengers on a tour through New York City, and the seaside of Boston and New Jersey.

Landing timeline

Around 7:00 p.m. local time, at an altitude of 650 feet (200 m), the Hindenburg approached the Lakehurst Naval Air Station. This was to be a high landing, known as a flying moor, because the airship would be moored to a high mooring point, and then winched down to ground level. This type of landing maneuver would reduce the number of ground crew, but would require more time.

7:08: the airship made a sharp full speed left turn to the west around the landing field because the ground crew was not ready.

7:11: the airship turned back toward the landing field and valved gas. All engines idled ahead and the airship began to slow.

7:14: at altitude 394 feet (120 m), Captain Pruss ordered aft engines full astern to try to brake the airship.

7:17: the wind shifted direction to southwest, and Captain Pruss was forced to make a second, sweeping sharp turn, this time towards starboard.
passenger had been injured on one of their airships. The Zeppelin company's promotions prominently featured the fact that no airship had flown safely for more than 1.6 million km (1 million miles), including the first round trip of the Graf Zeppelin in 1929.

There had been a series of other airship accidents, none of them Zeppelins, prior to the Hindenburg disaster. Many were caused by bad weather, and most of these accidents were dirigibles of British or U.S. manufacture. Both nations' techniques for dirigible manufacture were primitive compared to the expertise of the Germans. Zeppelins had had an impeccable safety record. The Graf Zeppelin had flown safely for more than 1.6 million km (1 million miles), including the first circumnavigation of the globe by an airship. The Zeppelin company's promotions prominently featured the fact that no passenger had been injured on one of their airships.

First hints of disaster

At 7:25, a few witnesses had seen the fabric ahead of the upper fin flutter as if gas were leaking. At the same time another witness saw what looked like static electricity moving up the hull from the bottom.

Immediately after this, witnesses started to report a small flame ahead of the upper fin. Commander Rosendahl testified it being "mushroom-shaped" and knew at once that the airship was doomed. One witness on the starboard side reported a fire beginning lower and behind the rudder on that side (however this may have happened after the initial fire on the port side).

The disaster

At 7:25 p.m. local time, the Hindenburg caught fire and quickly became engulfed in flames. Where the fire started is controversial: witnesses on the port side saw yellow, red flames first just forward of the top fin, around the vent of cell 4. One, with views of the starboard side, saw flames beginning lower and farther aft, near cell 1. No. 2 Helmsman Helmut Lau also testified seeing the flames spreading from cell 4 into starboard. (Although there were four newsreel cameramen and at least one spectator known to be filming the landing, they were all recording the actions of the ground crew when the fire started and therefore there is no motion picture record of where it first broke out at the instant of ignition.)

Wherever it started, the flames quickly spread forward. Almost instantly, a water tank and a fuel tank burst out of the hull, as seen in the picture on the right. At the same time, a crack appeared behind the passenger decks. The airship's back broke, and the section from the nose to the aft engine cars lurched upwards, while the stern stayed in trim.

As the Hindenburg's tail crashed into the ground, a burst of flame came out of the nose, killing three of the six crew members in the bow. As the airship kept falling with the bow facing upwards (because there was more lifting gas still in the nose), part of the port side directly behind the passenger deck collapsed inward (where the "dent" was), and the gas cell there exploded, erasing the scarlet lettering "Hindenburg" while the airship's bow lowered. The airship's gondola wheel touched the ground, causing the airship to bounce up once more. At this point, most of the fabric had burned away. At last, the airship went crashing on the ground, bow first.

The time it took for the airship to be completely destroyed has been disputed. Some believe it took 34 seconds, others say it took 32 or 37 seconds. Since none of the newsreel cameras were running when the fire started, the time of the start of the fire can only be estimated from various eyewitness accounts, and will never be known accurately. One careful analysis of the flame spread, by Addison Bain of NASA, gives the flame front spread rate across the fabric skin as about 49 ft/s (15 m/s), which would have resulted in a total destruction time of about 16 seconds (245m / 15m/s = 16.3s).

The incident is widely remembered as one of the most dramatic accidents of modern time. The cause of the accident has never been determined, although many theories, some highly controversial, have been proposed.

Historic newsreel coverage

The disaster is well recorded because of the significant extent of newsreel coverage and photographs, as well as Herbert Morrison's recorded, on-the-scene, eyewitness radio report being made from the landing field for station WLS in Chicago which was broadcast the next day. Heavy publicity about the first transatlantic passenger flight of the year by Zeppelin to the U.S. attracted a large number of journalists to the landing. (The airship had already made one round trip from Germany to Brazil that year.) Parts of the Morrison report were later dubbed onto the newsreel footage giving the impression to many modern viewers, more accustomed to live television reporting, that the words and film were recorded together intentionally. Morrison's broadcast remains one of the most famous in history. His plaintive words, "Oh, the humanity!" resonate with the impact of the disaster, and have been widely used in culture. Part of its poignancy is due to its being recorded at a disaster, and have been widely used in culture. Part of its poignancy is due to its being recorded at a moment of wonder, at a time when the world was captivated by the possibility of air travel and higher pitch; when corrected, his account is less frantic sounding, though still impassioned.

Spectacular motion picture footage and Morrison's passionate recording of the Hindenburg fire shattered public and industry faith in airships and marked the end of the giant passenger-carrying dirigibles. Also contributing to the Zeppelins' downfall was the arrival of international passenger aeroplane travel and Pan American Airlines, which regularly crossed the Atlantic and Pacific oceans much faster than the 130 km/h (80 mph) of the Hindenburg. The one advantage that the Hindenburg had over aircraft was the comfort it afforded its passengers, much like that of an ocean liner.

There had been a series of other airship accidents, none of them Zeppelins, prior to the Hindenburg fire. Many were caused by bad weather, and most of these accidents were dirigibles of British or U.S. manufacture. Both nations' techniques for dirigible manufacture were primitive compared to the expertise of the Germans. Zeppelins had had an impeccable safety record. The Graf Zeppelin had flown safely for more than 1.6 million km (1 million miles), including the first circumnavigation of the globe by an airship. The Zeppelin company's promotions prominently featured the fact that no passenger had been injured on one of their airships.
Death toll
Despite the violent fire, most of the crew and passengers survived. Of the 36 passengers and 61 crew, 13 passengers and 22 crew died. Also killed was one member of the ground crew, Navy Linesman Allen Hagaman. The two dogs on board the airship also died. Most deaths were not caused directly by the fire but were from jumping from the burning airship. Those passengers who rode the airship on its descent to the ground survived. Some deaths of crew members occurred because they wanted to save people on board the airship. In comparison, almost twice as many perished when the helium filled USS Akron crashed.[14]

Some of the survivors were saved by luck. Werner Franz, the 14 year-old cabin boy, had been saved from the fire by a shower of water. A water ballast tank burst open, and he was soaked. Then he made his way to the hatch and turned around and ran the other way, because the flames were being pushed by the wind towards the starboard side. Franz is one of the two people aboard who are still alive as of 2008. When the control car crashed on the ground, the officers Of the six people in the bow of the airship, three survived; the flames shot through the nose like a blowtorch and the airship tilted upwards. Most of the people had fallen into the fire but the three hung on tight.

The four crew members in the tail fin all survived; they were closest to the origin of the fire but escaped when the tail hit the ground.

Hydrogen fires are notable for being less destructive to immediate surroundings than gasoline explosions because of the buoyancy of H₂, which causes heat of combustion to be released upwards more than circumferentially as the leaked mass ascends in the atmosphere; hydrogen fires are more survivable than fires of gasoline and of wood.[15]

Cause of ignition

Sabotage theory
At the time of the disaster, sabotage was commonly put forward as the cause of the fire, in particular by Hugo Eckener, former head of the Zeppelin company and the "old man" of German airships. (Eckener later publicly endorsed the static spark theory — see below.)

Another proponent of the sabotage hypothesis was Max Pruss, commander of the Graf Zeppelin throughout the airship's career. Pruss flew on nearly every flight of the Graf Zeppelin until the Hindenburg was ready. In a 1960 interview conducted by Kenneth Leish for Columbia University's Oral History Research Office, Pruss said early dirigible travel was safe, and therefore he strongly believed that sabotage was to blame. He stated that on trips to South America, which was a popular destination for German tourists, both airships passed through thunderstorms and were struck by lightning but remained unharmed.[16]

In 1962, A. Hoehling published Who Destroyed the Hindenburg?, a book that rejects all theories but sabotage. It even names the likely saboteur — Eric Spehl, a rigger on the Hindenburg who died in the fire. Ten years later, Michael MacDonald Mooney's book, The Hindenburg, also identified Spehl as the saboteur. Mooney's book was made into the movie The Hindenburg, whose producers were sued by Hoehling for plagiarism, but Hoehling lost.[17]

The historians and researchers putting Spehl forward as a saboteur, cite:
- His girlfriend's anti-Nazi connections; she reportedly was a communist.
- The fire's origin near Gas Cell 4, Spehl's duty station.
- Rumours that in 1938 the Gestapo was investigating Spehl's involvement.
- Spehl's interest in amateur photography, making him familiar with flashbulbs that could have served as an igniter. A dry cell battery that might have powered a flashbulb was found in the wreckage.
- A flash or a bright reflection that crew members near the lower fin had seen just before the fire. Since it is very unlikely that Spehl wanted to kill people, proponents of this sabotage theory say that he wanted the airship to explode after the landing (already over 12 hours late) but was too busy to reset the bomb.

During the landing maneuver, rigger Hans Freund dropped a landing line in front of the lower fin. The line became caught in the bracing wires of the airship, so No. 2 helmsman Helmut Lau climbed up from the lower fin to release it. When both men looked up toward the front of the airship, they were surprised by what they saw.

Freund described a flash like a flashbulb's, and Lau said he saw a brilliant reflection between cells 4 and 5. They then heard a muffled detonation and a thud as the Hindenburg's back broke. Some believe that this is evidence for sabotage. Others believe Freund was actually looking rearward, away from cells 4 and 5, but that Rudolf Sauter, another crew member in the lower fin had seen the flash.[18]

Another suspect was a passenger, a German acrobat named Joseph Spah, who survived the fire. He brought with him a dog, a German shepherd named Ulla, as a surprise for his children. (Ulla did not survive.) He often made unaccompanied visits to the stern to feed, talk and play with the dog. Some, noting that Spah told many anti-Nazi jokes, and that he was an acrobat who could climb into the airship's rigging, accuse him of planting a bomb when he was with his dog.

It has even been suggested that Adolf Hitler himself ordered the Hindenburg to be destroyed in retaliation for Eckener's anti-Nazi opinions.[19]

However, opponents of the sabotage hypothesis argued that only speculation supported sabotage as a cause of the fire, and no credible evidence of sabotage was produced at any of the formal hearings.

Eric Spehl died in the fire and was unable to refute the accusations. The FBI investigated Joseph
Neither the German nor the American investigation endorsed any of the sabotage theories. Proponents of the sabotage theory argue that any finding of sabotage would have been an embarrassment for the Nazi regime, and they speculate that such a finding by the German investigation was suppressed for political reasons.

Eckener believed that the reason why Pruss, Lehmann, and Rosendahl all supported sabotage was because they may have felt guilty for their acts. Pruss made the sharp turn, Lehmann pressured Pruss to make it, and Rosendahl called the airship in.

Static spark theory

Another theory posits that the fire was started by a spark caused by a build up of static electricity on the airship. Whether the spark ignited hydrogen or the outer skin has been disputed.

Proponents of the static spark theory point out that the airship's skin was not constructed in a way that allowed its charge to be evenly distributed throughout the craft. The skin was separated from the duralumin frame by non-conductive ramie cords, in effect electrically insulating the skin from the frame and allowing a difference in potential to form between them.

In order to make up for a delay of more than 12 hours in its transatlantic flight, the Hindenburg passed through a weather front of high humidity and high electrical charge. This made the airship's mooring lines wet and thus conductive and may have given its skin an electrical charge. When the mooring lines, which were connected to the frame, touched the ground, they would have grounded the frame but not the skin. Though they were dry, they could have gotten wet as the light rain fell. This could have caused a sudden potential difference between skin and frame (and the airship itself with the overlying air masses) and set off an electrical discharge — a spark. The spark would have jumped from the skin onto the metal framework. At the same time, hydrogen was leaking, and was ignited by the spark.

Some witnesses reported seeing a glow consistent with St. Elmo's fire along the tail portion of the airship just before the flames broke out, but these reports were made after the official inquiries were completed.

Harold G. Dick was Goodyear Zeppelin's representative with Luftschiffbau Zeppelin during the mid-1930s. He flew on test flights of the Hindenburg and its sister ship, the Graf Zeppelin II. He also flew on numerous flights in the original Graf Zeppelin and 10 round trip crossings of the north and south Atlantic in the Hindenburg. In his book The Golden Age of the Great Passenger Airships Graf Zeppelin & Hindenburg, he observes:

"There are two items not in common knowledge. When the outer cover of the LZ 130 [the Graf Zeppelin II] was to be applied, the lacing cord was prestretched and run through dope as before, but the dope for the LZ 130 contained graphite to make it conductive. This would hardly have been necessary if the static discharge theory were mere cover up. The use of graphite dope was not publicized and I doubt if its use was widely known at the Luftschiffbau Zeppelin.

In addition to Dick's observations is the fact that during the Graf Zeppelin II's early test flights, measurements were taken of the airship's static charge. It is clear that Dr. Ludwig Durr and the other engineers at Luftschiffbau Zeppelin took the static discharge theory seriously and considered the insulation of the fabric from the frame to be a design flaw in the Hindenburg.

A variant of the static spark theory, presented by Addison Bain, is that a spark between inadequately grounded fabric cover segments of the Hindenburg itself started the fire, and that the spark had ignited the highly flammable outer skin. The Hindenburg had a cotton skin covered with a finish known as "dope". It is a common term for a plasticised lacquer that provides stiffness, protection, and a lightweight, airtight seal to woven fabrics. In its liquid forms, dope is highly flammable, but the flammability of dry dope depends upon its base constituents, with butyrate dope being far less flammable than cellulose nitrate, for example. When the mooring line touched the ground, a resulting spark could have ignited the dope in the skin.

Lightning theory

A. J. Dessler, former director of the Space Science Laboratory at NASA's Marshall Space Flight Center and a critic of the incendiary paint theory (see below), favors a much simpler explanation for the conflagration: natural lightning. Like many other aircraft, the Hindenburg had been struck by lightning several times. This does not normally ignite a fire in hydrogen-filled airships, because the hydrogen is not mixed with oxygen. However, many fires started when lightning struck airships as they were venting hydrogen in preparation for landing, as the Hindenburg was doing at the time of the disaster. The vented hydrogen is mixed with air, making it readily combustible.

However, Dr. Eckener believed that the way the fire appeared was not consistent with that of a fire caused by lightning. Witnesses described the fire appearing in a wave motion. Eckener believed that the shape of the fire was consistent with that of a static spark.

Engine exhaust sparks theory

On the 70th anniversary of the accident, The Philadelphia Inquirer carried an article with yet another theory, based on an interview of ground crew member Robert Buchanan. He had been a young man on the crew manning the mooring lines.

The excessively stormy day had not only delayed the dirigible's arrival but also soaked him and many of the other mooring crew. As the airship was approaching the mooring mast, he noted that one of the engines, thrown into reverse for a hard turn, backfired, and a shower of sparks was emitted. He and others think that this was the trigger that ignited the craft, not static electricity, as the official version goes.
When the Hindenburg ignited, instead of an explosion there were just three sequential plumes of flame on the outer shell. Another ground crewman named Robert Shaw saw what looked like a blue ring behind the tail fin. He too had seen sparks coming out of the engine. The cotton cover with its coating, was quite flammable (this is disputed), and the heat and sparks from the backfiring engine may have been the ignition source.

However, it is unknown if sparks could ignite the doping compound, and Dr. Eckener rejected that hydrogen could be ignited when the theory was mentioned at an unofficial inquiry at night. This was a chat with crew members. He believed that the hydrogen could not have been ignited by any exhaust because the temperature is too low to ignite the hydrogen. The ignition temperature for hydrogen is 700 °C, but the sparks from the exhaust only reach 250 °C. The Zeppelin Company also carried out extensive tests, and hydrogen could never be ignited. Additionally, the fire was first seen at the top of the airship, not near the bottom.

**Fire's initial fuel**

Most current analysis of the fire assumes that ignition due to some form of electricity was the cause. However, there is still controversy over whether the fabric covering of the airship or the hydrogen used for buoyancy was the initial fuel for the fire.

**The incendiary paint theory**

The incendiary paint theory asserts that the major component in the fire was the skin because of the doping compound used on it.

Proponents point out that the coatings on the fabric contained both iron oxide and aluminum-impregnated cellulose acetate butyrate (CAB). These components are potentially reactive, even after fully setting. In fact, iron oxide and aluminum are sometimes used as components of solid rocket fuel or thermite. The propellant for the Space Shuttle solid rocket booster includes "aluminum (fuel, 16%), (and) iron oxide (a catalyst, 0.4%)."

Addison Bain received permission from the German government to search its archives and discovered that during the Nazi regime, German scientists concluded that the dope on the Hindenburg's fabric skin was the cause of the conflagration. Bain interviewed the wife of the investigation's lead scientist, and she confirmed that her husband had told her about the conclusion and instructed her to tell no one, presumably because it would have embarrassed the Nazi government.

The paint theory is limited to the source of ignition and to the flame front propagation, not to the source of most of the burning material as that was clearly the hydrogen.

Critics point out that port side witnesses on the field, as well as crew members stationed in the stern, saw a glow inside Cell 4 before any fire broke out of the skin, indicating that the fire began inside the airship (or that it was a hydrogen fire feeding on the whole cell). Newsreel footage supports this.[11] Proponents of the paint theory claim that the glow can be explained. They claim that what witnesses saw was the fire on the starboard side (another proponent claims that a witness saw the fire start from the starboard side) through the structure, looking like a glow. However, photographs of the early stages of the fire show the gas cells of the Hindenburg's entire aft section fully aflame. Burning gas spewing upward from the top of the airship was causing low pressure inside, allowing atmospheric pressure to press the skin inwards. It should also be noted that not all fabric on the Hindenburg burned. The fabric on several of the tail structures was not completely consumed. That the fabric not near the hydrogen fire extinguished itself is not consistent with the "explosive" dope theory.

Mythbusters have further de-bunked the theory, finding that the aluminum/iron oxide ratios in the Hindenburg's skin were inconsistent with those required to create thermite. Had the skin in fact contained ratios consistent to thermite, the Hindenburg would have been some three times heavier. They also discovered that the Hindenburg's coated skin was more resistant to fire than untreated material, however, when ignited, reacted more violently.

**The hydrogen theory**

Those who believe hydrogen was the initial fuel discount arguments for the incendiary paint theory as not credible. They point out that cellulose acetate butyrate (CAB) varnish is rated within the plastics industry as combustible but nonflammable. That is, it will burn when placed in a fire but is not readily ignited by itself. In fact, it is considered to be self extinguishing. That many pieces of the Hindenburg's skin survived despite such a fierce fire is cited as proof. In his experiment, Addison Bain used a high energy ignition source (a spark) to make it burn.

\[
\text{Fe}_2\text{O}_3 + 2\text{Al} \rightarrow \text{Al}_2\text{O}_3 + 2\text{Fe} \quad \text{(aluminum and iron oxide reaction)}
\]

They point to pictures that show the fire burning along straight lines coinciding with the boundaries of gas cells. This suggests that the fire was not burning along the skin, which was continuous. Crew members stationed in the stem reported actually seeing the cells burning.

Although the hydrogen was odorised with garlic, nobody reported smelling the odor. Odorised hydrogen would have been detected only in the area of a leak. The fire started near the top of the airship far from any crew or passengers. Once the fire was underway, more powerful smells would have masked any garlic odor. There is however, no official document that the hydrogen was even odorized.

Support that any leak happened was that the airship remained stern heavy for the last few minutes. Though Pruss believed that this stern heaviness was normal, attempts to correct it had failed and the airship seemed to get even heavier after the second and last sharp turn. This suggests a massive leak of gas occurred and it started to fill up the space in between the outer skin and the cells.
How gas could have leaked remains debatable. Many believe it was that a bracing wire cracked (see below), while others believe that a vent was stuck open and gas leaked through the vent. During a trip to Rio a gas cell was nearly emptied when a vent stuck open; gas had to be transferred from other cells.[1]

Puncture theory
A variant of the theory above cites the newsreels of the landing approach. Newsreels show the Hindenburg making sharp turns towards port, and then starboard just before bursting into flames. Some speculate that one of the many bracing wires within the airship snapped and punctured at least one of the internal gas cells. Gauges found in the wreckage showed the tension of the wires was much too high. Some of the wires may have been substandard. One bracing wire tested after the crash broke at only 70% of its rated load.[1] A punctured cell would have freed hydrogen into the air and could have been ignited by a static discharge (see above).

It is also possible that the broken bracing wire then whipped a girder, causing sparks to ignite the leaking hydrogen.[1]

A ground crew member, R.H. Ward, reported seeing a piece of the airship fluttering, perhaps providing an opening for a spark to reach escaping hydrogen inside the airship, or vice versa. He said that the fire began there, but that no other disturbance occurred at the time when the fabric fluttered.[2] Another man on the top of the mooring mast had also reported seeing a flutter too.[2]

People on board the airship also reported hearing a muffled sound, and another ground crew member on the starboard side reported hearing a crack. Some speculate the sound was from a bracing wire snapping.[1]

Advocates of this theory believe that the hydrogen began to leak approximately five minutes before the fire.[2]

Dr. Eckener was the one to conclude that the puncture theory was the most likely cause of the disaster. After this, he believed that Captains Pruss and Lehmann, and Charles Rosendahl were to blame for the whole disaster.[2] He believed that Lehmann told Pruss to make the sharp turn, and that Pruss and Rosendahl were concerned more about the time delay than the weather, because an unobserved storm front occurred just when the Hindenburg approached.[2] But in his heart, he found himself to blame, for a decision eight years earlier, which was a close secret.[2]

Eckener concluded that the fire was caused by the ignition of hydrogen by a static spark.[2]

I believe the fire was not caused by an electrical spark, but by a static spark. A thunderstorm front had passed before the landing maneuver. However if one observes more closely one can see that this was followed by a smaller storm front. This created conditions suitable for static sparks to occur. I believe spark had ignited gas in the rear of the ship. It may seem strange that the fire did not occur the moment the landing ropes had touched the ground, because that is when the airship would have been earthed. I believe there is an explanation for this. When the ropes were first dropped they were very dry, and poor conductors. Slowly however they got dampened by the rain that was falling and the charge was slowly equalized. Thus the potential difference between the airship and the overlying air masses would have been sufficient enough to generate static electricity. The Hindenburg would have acted as a giant kite, close to the storm clouds, collecting a static spark.

I am convinced, that a leak must have occurred in the upper rear section of the ship. My assumption is confirmed by the remarkable observations by one of the witnesses. He described seeing a peculiar flutter as if gas were rising and escaping. If I were to be asked to explain what had caused this abnormal build up of gas, I could only make to myself one explanation.

The ship proceeded in a sharp turn during its landing maneuver. This would have generated extremely high tension in the sections close to the stabilizing fins, which are braced by shear wires. I suspect that under such tension one of these wires may have broken and caused a rip in one of the gas cells. The gas then filled up the space between the cell and the outer cover, which is why the airship sank at the rear. This accumulated amount of gas was then ignited by a static spark. This was not lightning but a small static spark, enough to ignite free gas in the rear.

One must know that the airship actually proceeded in two sharp turns. The first turn was towards port at full speed as the airship circled the landing field. After circling the landing field, the wind shifted direction towards southwest, and a sharper turn towards starboard was ordered near the end of the landing maneuver. After the last turn the airship seemed to drop even more at the stern, though a slight stern heaviness was already noticed before this turn. One or both of these turns towards opposite directions could also have weakened the structure.

Other controversial hypotheses

STRUCTURAL FAILURE
Captain Pruss believed that the Hindenburg could withstand tight turns without significant damage. Others believe that the airship would have been weakened by being repeatedly stressed. Even a 10 meter, full scale replica of the Hindenburg's passenger quarters, displayed in the Zeppelin Museum in Friedrichshafen, has developed some metal fatigue.

The airship did not receive much routine inspection, even though there was evidence of some damage on previous flights. It is not known if damage was repaired and if all the failures had been found. The Hindenburg once lost an engine and almost drifted over Africa, where it could have crashed. Dr. Eckener was furious and ordered all section chiefs to inspect the airship during flight.
In March 1936, the Graf Zeppelin and the Hindenburg made three-day flights to drop leaflets and broadcast speeches via loudspeaker. Before the airship's takeoff on 26 March 1936, Captain Lehmann chose to launch the Hindenburg with the wind blowing from behind the airship, instead of into the wind as per standard procedure. During the takeoff, the airship's tail struck the ground, and part of the lower fin was broken. Many spectators' cameras were confiscated to prevent negative publicity, but Harold G. Dick concealed his camera and took pictures of the damaged fin. Dr. Eckener was very upset and rebuked Captain Lehmann:

How could you, Herr Lehmann, order the ship to be brought out in such wind conditions. You had the best excuse in the world for postponing this idiotic flight; instead, you risk the ship, merely to avoid annoying Herr Goebbels. Do you call this showing a sense of responsibility towards our enterprise 23,24

Though the damage was repaired, the force of the crash may have already forced up the fin and caused internal damage.

Only six days before the disaster, there was a plan assisted by the U.S. Navy to make the Hindenburg have a hook on her hull to carry aircraft in a similar way to what the Navy did with the USS Akron and the USS Macon. However, the trials were unsuccessful; the biplane had bashed the hook several times. This could have also caused an amount of damage weakening the structure.

Photographs and Newsreels of the disaster show that the stern section of the airship collapsed inward in a similar way to an eggshell, with an inward dent directly behind the passenger decks, which appeared the moment the airship burned. When the airship collapsed with the bow facing upwards, this part collapsed inward, causing another plume of fire to start.

This theory of the cause of the fire has not been very popular, because it does not explain exactly why the fire started, instead supporting the puncture theory.

FUEL LEAK
The 2001 documentary Hindenburg Disaster: Probable Cause suggested that 16-year-old Bobby Rutan, who said he had smelled "gasoline" when he was standing below the Hindenburg's aft port engine, had detected a diesel fuel leak. The day before the disaster a fuel pump had broken during the flight. A crew member said this was fixed but it may not have been. The resulting vapor would have been highly flammable and could have self combusted. The film also suggested that overheating engines may have played a role.

During the investigation, Commander Charles Rosendahl dismissed the boy's report.

Critics say the documentary is misleading, because it misconstrued the statements by the crewmen in the Hindenburg's lower fin. The crewmen said they saw a flash in the axial catwalk, but the film placed the flash in the keel catwalk closer to the passenger areas.

LUGER PISTOL AMONG WRECKAGE
Some more sensational newspapers at the time said that a person on board committed suicide because a Luger pistol with one shell fired was found among the wreckage. Yet, there is no such evidence suggesting an attempted suicide. It is important to note that the Luger pistol is an automatic pistol which automatically extracts each spent cartridge. It is not unusual for owners of automatics to leave one spent cartridge in the chamber as a safety precaution precluding accidental discharge.

Rate of flame propagation
Regardless of the source of ignition or the initial fuel for the fire, there remains the question of what caused the rapid spread of flames along the length of the airship. Here again the debate has centered on the fabric covering of the airship and the hydrogen used for buoyancy.

Proponents of the incendiary paint theory also contend that the fabric coatings were responsible for the rapid spread of the fire. They point out that the combustion of hydrogen is not usually visible to the human eye in daylight, because most of its radiation is not in the visible portion of the spectrum. Thus what can be seen burning in the photographs cannot be hydrogen. However, black and white photographic film of the era had a different light sensitivity spectrum than the human eye, and was sensitive farther out into the infrared and ultraviolet region than the human eye. The motion picture films show the fire spreading downward along the skin of the airship.

Proponents claim that in 1935, a helium filled blimp with an acetate aluminium skin burned near Point Sur in California with equal ferocity. Proponents also claim that even the USS Macon burned. Opponents point out that these two incidents had nothing to do with the dope. The small blimp burned because of a fuel leak, and the Macon burned because it was firing flares.

Those skeptical of the incendiary paint theory cite recent technical papers which claim that even if the airship had been coated with actual rocket fuel, it would have taken many hours to burn — not the 32 to 37 seconds that it actually took. Proponents claim that this criticism does not take into account the conditions that lead to firestorms, such as convection and ignition from radiant energy.

Also, while hydrogen tends to burn invisibly, the materials around it would be combustible and change the color of the fire. While fires generally tend to burn upward, including hydrogen fires, the enormous radiant heat from the blaze would have quickly spread fire over the entire surface of the airship, thus explaining the downward propagation of the flames. Falling, burning debris would appear as downward streaks of fire.
The most conclusive proof against the fabric theory is in the photographs of the actual accident as well as the many airships which were not doped with aluminum powder and still exploded violently. When a single gas cell explodes, it creates a shock wave and heat. The shock wave tends to rip nearby bags which then explode themselves. In the case of the Alhorn disaster during World War I, explosions of airships in one shed caused the explosions of others in sheds nearby, wiping out the airships at the base.

The photos of the Hindenburg disaster clearly show that after the cells in the aft section of the airship exploded and the combustion products were vented out the top of the airship, the fabric on the rear section was still largely intact, and air pressure from the outside was acting upon it, caving the sides of the airship inward due to the reduction of pressure caused by the venting of combustion gases out the top.

The loss of lift at the rear caused the airship to nose up and the back to break (the airship is still in one piece), at that time the primary mode of spread for the fire was along the axial gangway which acted as a chimney conducting fire which burst out the nose right when the airship's tail touched the ground, as seen in one of the most famous pictures of the disaster. As the flames burst from the nose, the fabric on most of the forward part of the airship was still intact, showing that the propagation of the fire was via hydrogen, not the fabric.

Also supporting the fact that hydrogen was burning was that a few seconds after the fire burst out the nose a fire started in the cell behind the passenger decks when the airship bent on the side due to a crack in the side just behind the passenger decks.

Modern experiments that recreated the fabric and coating materials of the Hindenburg seem to discredit the incendiary fabric theory. They conclude that it would have taken about 40 hours for the Hindenburg to burn if the fire had been driven by combustible fabric. Two additional scientific papers also strongly reject the fabric theory.

Even if the fire was started by the fabric, it would have set off the leaking hydrogen. Hydrogen would still be required to increase the burn speed of the fire, regardless of what was ignited first. If the Hindenburg was filled with helium and still burned, the fire would be slower and most people, if not all, would have survived.

**Television investigations**

The Discovery Channel series *MythBusters* explored the incendiary paint theory (IPT) and the hydrogen theory in an episode that aired 10 January 2007. The show's hosts, Adam Savage and Jamie Hyneman, demonstrated that when set alight with a blowtorch a 1:50 scale model of the Hindenburg burnt twice as fast in the presence of diffused hydrogen as without it. The *thermite* reaction was observed in the burning skin which would have accelerated the fire but they concluded that hydrogen was the main fuel. The hydrogen filled model produced a fire with flames that came out of the nose and resembled the newsreel footage of the Hindenburg disaster.

The program concluded that the IPT myth was "Busted".

The National Geographic program *Seconds From Disaster* had air crash investigator Greg Feith study all of the available evidence, including eyewitness accounts, interviews with the last two living survivors, newsreel footage, weather reports, & the Hindenburg blueprints. In the program Feith burns a sample of doped cloth and it took one minute to burn the whole piece. He concludes that the skin could not be the fatal accelerant. The program concludes that the puncture theory remains the most probable cause, as the airship made two sharp turns.

*In Search of...*, hosted by Leonard Nimoy, made an episode based on this tragic accident, and it immediately raises the question of whether it was an accident or a sabotage made by then-Nazi Germany.

**Memorial**

The actual site of the Hindenburg crash at Lakehurst Naval Air Station (reestablished as Naval Air Systems Command (NAVAIR) at Naval Air Engineering Station (NAES) Lakehurst, or "Navy Lakehurst" for short) is marked with a chain outlined pad and bronze plaque where the airship's gondola landed. It was dedicated on 6 May 1987, the 50th anniversary of the disaster. Hangar #1, which still stands, is where the airship was to be housed after landing. It was designated a Registered National Historic Landmark in 1968. Pre-registered tours are held through the Navy Lakehurst Historical Society. Due to security concerns, no foreign nationals are permitted on the tour.

**Popular culture**

**Audio**

- English rock group Led Zeppelin's *eponymous first album* has a picture of the Hindenburg disaster on the front cover. The band's name itself is a reference to Keith Moon's quotation that the band would "go over like a lead balloon." The album cover is in fact a pen and ink illustration of the famous *UPI* photograph drawn with a Rapidograph pen by graphic artist George Hardie. Their 2007 compilation album Motherson also has a picture of the Hindenburg on the album cover.
- Folk/blues musician Huddie Ledbetter (AKA Leadbelly) wrote a two-part song about the Hindenburg crash called "The Hindenburg Disaster".
- Richard M. Sherman and Mit Larsen's 1960s-era satirical album, *Smash Flops* contains "When the Hindenberg Lands Today" including lyrics: "There'll be a hot hot time in Lakehurst, New Jersey, when the Hindenberg lands today" as well as "and we know that your motto is 'New
Film and television

- Actual footage of the Hindenburg is shown in the 1937 Charlie Chan film Charlie Chan at the Olympics, recently released on DVD by 20th Century Fox films. The movie depicts Chan onboard for a flight across the Atlantic, and mentions nothing concerning the disaster.
- The Hindenburg (1975 movie) is a speculative thriller based on the events leading up to and including the disaster.
- In the film Indiana Jones and the Last Crusade Indy and his father board the LZ 138 Zeppelin; Indy swaps a plane and flies away (to hangar planes aboard an airship was however an exclusive US Navy invention).
- The movie The Rocketeer concludes with a final confrontation between hero and villain set in and on the Zeppelin Luxemburg, which explodes Hindenburg-style over the hills of Hollywood.
- The film Sky Captain and the World of Tomorrow opens with the Hindenburg ill approaching the Empire State Building to dock (the building was originally designed to serve this purpose).
- The Discovery Channel television show Mythbusters produced an episode that demonstrates with a scale model how they believe the Hindenburg caught on fire.

Other

- The Hindenburg is the primary motif of the first section of Three Tales by Steve Reich and Beryl Korot.
- The last flight of the Hindenburg is a major plot element in Allen Steele's science fiction novel Chronospace (the relevant part previously published as a stand alone novella "...Where Angels Fear to Tread", winning the Hugo Award for Best Novella in 1998). Two researchers from the future travel to 1937 and replace Mr. and Mrs. Pannes, real passengers who were killed in the disaster, and inadvertently prevent the Hindenburg from being destroyed until after the passengers and crew disembark. The novel assumes that Eric Spellic planted a flashbulb-triggered bomb in gas cell 4.
- In the novel The Never War by D.J. MacHale, the main character can choose to keep the Hindenburg Disaster from happening, which he thought would keep World War II from starting. However, he decides not to, since he discovers that the airship is carrying payment to German spies that would allow the Nazis to develop atomic weapons before the Allies.
- "Weird" Al Yankovic uses the line, "Oh, the humanity!", on Couch Potato, (from "Poodle Hat") 2005.

See also

- Hindenburg Disaster newsreel footage
- Herbert Morrison (announcer)
- List of airship accidents
- Zeppelin
- Harold G. Dick was an American engineer who flew on most of the Hindenburg flights.
- The Zeppelin Museum Friedrichshafen displays a reconstruction of a 33 m section of the Hindenburg.
- Hindenburg: The Untold Story was a doctudrama aired on the 70th anniversary of the disaster, 6 May 2007.

References

Notes

1. ^ a b d e Moondance Films, Hindenburg Disaster: Probable Cause (2001), also known as Revealed... The Hindenburg Mystery (2002)
3. ^ Data
8. ^ Birchall, 1936
11. ^ http://www.youtube.com/watch?v=VMjaeRvYY70
12. ^ While Hindenburg Disaster: Probable Cause states that all six crew members were killed, three of them survived (Hindenburg: The Untold Story)
13. ^ Blimps, dirigibles and Zeppelins are categorized as "airships." Planes and helicopters are categorized as "winged aircraft." The term aerostat is reserved for balloons.
16. ^ Columbia University's Oral History Research Office interview
17. ^ Hoehling
18. ^ Archbold 1994
37. An article supporting the engine exhaust spark theory: "The real cause of the Hindenburg disaster?" Transcribed from Herb Morrison’s famous report synchronized with newsreel footage from the disaster.

38. Thirty-two Seconds - a detailed account of the disaster that features rare photos of the disaster, a photograph of the Hindenburg, and a rare interview with the salvage operations commander.

Bibliography


External links

Wikimedia Commons has media related to: LZ 129 Hindenburg

Video

Footage from Castle and Pathé coverage of the Hindenburg disaster at Internet Archive.
- YouTube video of Herb Morrison’s famous report synchronized with newsreel footage.

Articles

- Hindenburg: Sky Cruise. Illustrated account of a flight on the Hindenburg - with maiden voyage and final flight passenger lists.
- Page at Great Zeppelins website, with various pictures.
- The Hindenburg in the development of zeppelins.
- Hindenburg & Hydrogen.
- FBI investigation into the Hindenburg disaster.
- Harold G. Dick Airship Collection (Harold G. Dick was an American engineer who flew on most Hindenburg flights.)
- "The Hindenburg" - Failure Magazine (January 2002)
- "The Hindenburg" - Zeppelin Luftschifftechnik GmbH & Co KG. The company is still in the airship business today.
- Thirty Two Seconds - An article about the disaster that features rare photos of the disaster, a photograph of the surviving crew and a report on Cabin Boy Werner Franz.
- "What Happened to the Hindenburg?" Transcript: Secrets of the Dead (15 June 2001, PBS)
- Passenger and Crew List of the Hindenburg on its final voyage.

FLAMMABLE FABRIC DISASTER THEORY

- Two Articles Rejecting the Flammable Fabric Theory.
- Experiments Related to the Flammable Fabric Theory.
- An article supporting the engine exhaust spark theory: "The real cause of the Hindenburg disaster?" Philadelphia Inquirer, 6 May 2007 (the 70th anniversary of the Hindenburg disaster).
Giant aircraft (Heavier-than-air)

Production
- Airbus A380
- Antonov An-124 Ruslan
- Antonov An-225 Mriya
- Boeing 747 (SP-400 LCF)
- JRM Mars
- Lockheed C-5 Galaxy

Prototypes
- Bristol Brabazon
- Convair XC-99
- Hughes H-4 Hercules
- Lockheed R6V Constitution
- Saunders-Roe Princess

Concepts
- Proposed Concepts: Reaction Engines A2
- Beriev Be-2500
- Boeing 747-8
- McDonnell Douglas MD-12

Other Aircraft Types
- Biggest Airship: Luftschiffbau Zeppelin LZ 129 Hindenburg
- Biggest Blimp: Goodyear ZPG-3W
- Biggest Helicopter: Mil Mi-12

Lists relating to aviation

General
- Timeline of aviation
- Aircraft (manufacturers)
- Aircraft engines (manufacturers)
- Airports
- Airlines
- Air forces
- Aircraft weapons
- Missiles
- Unmanned aerial vehicles (UAVs)
- Experimental aircraft

Military
- Airspeed
- Distance
- Altitude
- Endurance
- Most-produced aircraft

Accidents/incidents
- General
- Military
- Commercial (airliners)
- Deaths

Records
- Airspeed
- Distance
- Altitude
- Endurance
- Most-produced aircraft

Coordinates: 40°01′49″N, 74°19′33″W

Results from FactBites:

Hindenburg disaster (484 words)

On May 6, 1937 at 19:25 the German zeppelin Hindenburg caught fire and was utterly destroyed within a minute while attempting to dock with its mooring mast at Lakehurst Naval Air Station in New Jersey.

The Hindenburg was intended to be filled with helium but a United States military embargo on helium forced the Germans to use highly flammable hydrogen as the lift gas.

Also, the naturally odorless hydrogen gas in the Hindenburg was 'odorised' with garlic so that any leaks could be detected, and nobody reported any smell of garlic during the flight or at the landing prior to the disaster.

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largest airship by envelope volume. It was designed and built by the Zeppelin Company (Luftschiffbau Zeppelin GmbH) on the shores of Lake Constance in Friedrichshafen and was operated by the German Zeppelin Airline Company (Deutsche Zeppelin-Reederei). LZ 129 Hindenburg. Design and development. Use of hydrogen instead of helium.