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Eagle Dynamics

# **Bf109K-4**

## **KURFÜRST**



# **DCS Bf 109 K-4 Kurfürst**

# **Flight Manual**

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Thank you for your purchase of DCS: Bf 109 K-4. DCS: Bf 109 K-4 is a simulation of a legendary German World War II fighter, and is the fifth installment in the Digital Combat Simulator (DCS) series of PC combat simulations.

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As operators of one of the largest collections of restored World War II aircraft, we at The Fighter Collection and the development team at Eagle Dynamics were fortunate to be able to take advantage of our intimate knowledge of WWII aviation to ensure the DCS model is one of the most accurate virtual reproductions of this aircraft ever made. Combined with volumes of outside research and documentation, the field trips to the TFC hangar and countless consultations and tests by TFC pilots were invaluable in the creation of this simulation.

The contents of this manual are based largely on actual vintage Bf 109 K-4 manuals of the aircraft's service era.

With homage to the brave pilots of World War II, we hope you enjoy taking this true Flying Legend to the skies and into the fight!

Sincerely,

The DCS: Bf 109 K-4 Development Team

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# INTRODUCTION



## INTRODUCTION



**Figure 1: Bf 109 E in flight**

## Birth of the Bf 109

One of the most well-known fighters of WWII had humble beginnings. When first imagined in 1933, just as a new political party rose to power in Germany, few people could have imagined that this early interceptor research project would result in over 30,000 production examples serving throughout Europe in roles ranging from ground attack to reconnaissance, and providing a mount to most of the world's leading fighter aces.

The Luftwaffe (German Air Force) had already been secretly working on military aviation throughout the 1920s and early 1930s. Bomber and fighter designs were disguised as civilian aircraft. The earliest plans that eventually resulted in the Bf 109 were shrouded in the same secrecy. Hermann Göring, freshly appointed Reichsminister of Aviation, in an October 1933 letter to Theo Croneiß, a man recently appointed to lead the little-known aircraft manufacturer Bayerische Flugzeugwerke (BFW, Bavarian Aircraft Works), wrote of an impending design competition for a "high-speed courier plane which does not need to be anything more than a single seater". BFW began preparing to build a fast civilian single-seater that could be converted into a fighter when needed.

At the same time, the Technisches Amt ("C-Amt"), the technical department of the newly created Reichsluftfahrtministerium (RLM, Reich Aviation Ministry), concluded a series of research projects into the future of air combat. The result of the studies were four broad outlines for future aircraft:

Rüstungsflugzeug I for a multi-seat medium bomber; Rüstungsflugzeug II for a tactical bomber; Rüstungsflugzeug III for a single-seat fighter, and Rüstungsflugzeug IV for a two-seat heavy fighter.

The plans for a single-seat fighter were published in the document L.A. 1432/33.

The fighter needed to have a top speed of 400 km/h (250 mph) at 6,000 m (19,690 ft), to be maintained for 20 minutes, while having a total flight duration of 90 minutes. The critical altitude of 6,000 meters was to be reached in no more than 17 minutes, and the fighter was to have an operational ceiling of 10,000 metres. The powerplant was to be the new Junkers Jumo 210, but the proviso was made that it would be interchangeable with the more powerful, but less developed Daimler-Benz DB 600 powerplant.

The new fighter was to be armed with either a single 20 mm MG C/30 engine-mounted cannon firing through the propeller hub as a Motorkanone or, alternatively, either two engine cowl-mounted 7.92 mm (.312 in) MG 17 machine guns, or one lightweight, engine-mounted 20 mm MG FF cannon with two 7.92 mm MG 17s. It was also specified that the wing loading should be kept below 100 kg/m<sup>2</sup>. The performance was to be evaluated based on the fighter's level speed, rate of climb, and maneuverability, in that order.



**Figure 2: Luftwaffe pilots of JG 53 "Ace of Spades" resting in front of an early Bf 109 E-3 in 1939**

Two pillars of the German aviation industry, Arado and Heinkel, received the development contract for the L.A. 1432/33 requirements at the same time in February 1934. Bayerische Flugzeugwerke (BFW) was also invited to participate in the competition. BFW was considered unlikely to win. It had just come back from a 1931 bankruptcy caused by several high-profile crashes of the BFW M.20

transport aircraft in service of the Luft Hansa. The first crash took the life of Hans Hackmack, a close friend of Erhard Milch, then head of Luft Hansa and the German civil aviation authorities. Milch was infuriated by what he considered a very callous response to the crash from Willy Messerschmitt, the M.20's designer. This led to lifelong hatred. Now appointed RLM director, Milch was unlikely to award RLM's first fighter contract to the man he despised.

Willy Messerschmitt was at the time designing aircraft for a Romanian airline. Summoned to Berlin and asked in no uncertain terms to get with the times and start working for Germany, Messerschmitt was allowed to look at the new requirements. Taking some time to review the specs, Messerschmitt eventually returned with a very unfavorable opinion. In his view, if built to requirements, a new fighter would be immediately obsolete, unable to catch up to a modern bomber. Technisches Amt leadership in the face of Generalstabschef Walther Wever were intelligent enough to see the truth in Messerschmitt's opinion, and the contract given to BFW was free of any preconditions. Willy Messerschmitt got a carte blanche to build the best modern fighter he could.



**Figure 3: Bf 109 G-10**

A fourth company, Focke-Wulf, received a copy of the development contract only in September 1934. Each company was asked to deliver three prototypes for head-to-head testing in late 1934.

Design work on Messerschmitt Project Number P.1034 began in March 1934, just three weeks after the development contract was awarded.

## Design Features

As with the earlier Bf 108 transport plane, the new design was based on Messerschmitt's "lightweight construction" principle, which aimed to minimize the number of separate parts in the aircraft. Examples of this could be found in the use of two large, complex brackets which were fitted to the firewall. These brackets incorporated the lower engine mounts and landing gear pivot point into one unit. A large forging attached to the firewall housed the main spar pick-up points, and carried most of the wing loads. Contemporary design practice was usually to have these main load-bearing structures mounted on different parts of the airframe, with the loads being distributed through the structure via a series of strong-points. By concentrating the loads in the firewall, the structure of the Bf 109 could be made relatively light and uncomplicated.



**Figure 4: Bf 109 G-2 Landing Gear**

An advantage of this design was that the main landing gear, which retracted through an 85-degree angle, was attached to the fuselage, making it possible to completely remove the wings for servicing without additional equipment to support the fuselage. It also allowed simplification of the wing structure, since it did not have to bear the loads imposed during takeoff or landing. The one major drawback of this landing gear arrangement was its narrow wheel track, making the aircraft unstable while on the ground. To increase stability, the legs were splayed outward somewhat, creating

another problem in that the loads imposed during takeoff and landing were transferred up through the legs at an angle.



**Figure 5: Bf 109 G-2 Tail**

The small rudder of the Bf 109 was relatively ineffective at controlling the strong swing created by the powerful slipstream of the propeller during the early portion of the takeoff roll, and this sideways drift created disproportionate loads on the wheel opposite to the swing. If the forces imposed were large enough, the pivot point broke and the landing gear leg would collapse outward into its bay. Experienced pilots reported that the swing was easy to control, but some of the less-experienced pilots lost fighters on takeoff.



**Figure 6: Bf 109 F-4 Landing**

Because of the large ground angle caused by the long legs, forward visibility while on the ground was very poor, a problem exacerbated by the sideways-opening canopy. This meant that pilots had to taxi

in a sinuous fashion which also imposed stresses on the splayed undercarriage legs. Ground accidents were a problem with rookie pilots, especially during the later stages of the war when pilots received less training before being sent to operational units. At least 10% of all Bf 109s were lost in takeoff and landing accidents, 1,500 of which occurred between 1939 and 1941. The problem would persist for nearly a decade until the installation of a fixed "tall" tailwheel on some of the late G-10s and 14s and the K-series.



**Figure 7: Bf 109 F-4**

From the inception of the design, priority was given to easy access to the powerplant, fuselage weapons and other systems while the aircraft was operating from forward airfields. To this end, the entire engine cowling was made up of large, easily removable panels which were secured by large toggle latches. A large panel under the wing center section could be removed to gain access to the L-shaped main fuel tank, which was sited partly under the cockpit floor and partly behind the rear cockpit bulkhead. Other, smaller panels gave easy access to the cooling system and electrical equipment. The engine was held in two large, forged, magnesium alloy Y-shaped legs which were cantilevered from the firewall. Each of the legs was secured by two quick-release screw fittings on the firewall. All of the main pipe connections were color-coded and grouped in one place, where possible, and electrical equipment plugged into junction boxes mounted on the firewall. The entire powerplant could be removed or replaced as a unit in a matter of minutes.

Another example of the Bf 109's advanced design was the use of a single, I-beam main spar in the wing, positioned more aft than usual (to give enough room for the retracted wheel), thus forming a stiff D-shaped torsion box. Most aircraft of the era used two spars, near the front and rear edges of the wings, but the D-box was much stiffer torsionally, and eliminated the need for the rear spar. The wing profile was the NACA 2R1 14.2 at the root and NACA 2R1 11.35 at the tip, with a thickness to chord ratio of 14.2% at the root and 11.35% at the tip.

Another major difference from competing designs was the higher wing loading. While the R-IV contract called for a wing loading of less than 100 kg/m<sup>2</sup>, Messerschmitt felt this was unreasonable. With low wing loading and the engines available, a fighter would end up being slower than the bombers it was tasked with catching.



**Figure 8: Augsburg, 1941 – assembly line of the Messerschmitt GmbH Regensburg – Obertraubling**

A smaller wing area was optimal for achieving high speed, but low-speed flight would suffer, as the smaller wing would require more airflow to generate enough lift to maintain flight. To compensate for this, the Bf 109 included advanced high-lift devices on the wings, including automatically-opening leading edge slats, and fairly large camber-changing flaps on the trailing edge. The slats increased the lift of the wing considerably when deployed, greatly improving the horizontal maneuverability of the aircraft. Messerschmitt also included ailerons that "drooped" when the flaps were lowered, thereby increasing the effective flap area. When deployed, these devices effectively increased the wings' coefficient of lift.

Reflecting Messerschmitt's belief in low-weight, low-drag, simple monoplanes, the armament was placed in the fuselage. This kept the wings very thin and light. Two synchronized machine guns were mounted in the cowling, firing over the top of the engine and through wing loading the propeller arc.

An alternative arrangement was also designed, consisting of a single cannon firing through a blast tube between the cylinder banks of the engine, known as a Motorkanone mount in German.

## Design Competition

The basic mock-up was completed by May, and a more detailed design mock-up was ready by January 1935. The RLM designated the design as type "Bf 109," the next available from a block of numbers assigned to BFW.

The first prototype (Versuchsfugzeug 1 or V1), with civilian registration D-IABI, was completed by May 1935, but the new engines were not yet ready. In order to get the "R III" designs into the air, the RLM acquired four Rolls-Royce Kestrel VI engines by trading Rolls-Royce a Heinkel He 70 Blitz for use as an engine test-bed. Messerschmitt received two of these engines and adapted the engine mounts of V1 to take the V-12 engine upright. V1 made its maiden flight at the end of May 1935 at the airfield located in the southernmost Augsburg neighborhood of Haunstetten, piloted by Hans-Dietrich "Bubi" Knoetzsch. After four months of flight testing, the aircraft was delivered in September to the Luftwaffe's central test center at the Erprobungsstelle Rechlin to take part in the design competition.

In the late summer of 1935, the first Jumo engines became available, so V2 was completed in October using the 449 kW (600 HP) Jumo 210A engine. V3 followed, the first to be mounted with guns, but it did not fly until May 1936 due to a delay in procuring another Jumo 210 engine.

After Luftwaffe acceptance trials were completed at their central Erprobungsstelle military aviation test and development facility at Rechlin, the prototypes were moved to the Baltic seacoast's E-Stelle facility at Travemünde for the head-to-head portion of the competition. The aircraft participating in the trials were the Arado Ar 80 V3, the Focke-Wulf Fw 159 V3, the Heinkel He 112 V4 and the Bf 109 V2. The He 112 arrived first, in early February 1936, followed by the rest of the prototypes by the end of the month.

Because most fighter pilots of the Luftwaffe were used to biplanes with open cockpits, low wing loading, light g-forces and easy handling like the Heinkel He 51, they were very critical of the Bf 109 at first. Ernst Udet, WWI ace and world-famous stunt pilot, invited to the Luftwaffe and slated to become its Director of Research and Development, initially had a very unfavorable opinion of the 109. When he first saw the new fighter, he told Messerschmitt to open the cockpit, so the pilot could feel the speed; and to add another wing on top of the first one with struts and wires. Otherwise, he said, the Bf 109 "would never be a fighter". A single test-flight in the 109 radically changed his opinion however.

The 109 soon became one of the frontrunners in the contest, alongside the Heinkel He 112. The Arado and Focke-Wulf entries, which were intended as "back-up" programmes to safeguard against failure of the two favorites, proved to be completely outclassed. The Arado Ar 80, with its gull wing (replaced with a straight, tapered wing on the V3) and fixed, spatted undercarriage was overweight and underpowered, and the design was abandoned after three prototypes had been built. The parasol winged Fw 159, potentially inspired by the same firm's earlier Focke-Wulf Fw 56, was always considered by the E-Stelle Travemünde facility's staff to be a compromise between a biplane and an aerodynamically more efficient, low-wing monoplane. Although it had some advanced features, it used a novel, complex retractable main undercarriage which proved to be unreliable.



**Figure 9: Bf 109 V2**

Initially, the Bf 109 was regarded with disfavor by E-Stelle test pilots because of its steep ground angle, which resulted in poor forward visibility when taxiing; the sideways-hinged cockpit canopy, which could not be opened in flight; the high wing loading; and the automatic leading edge slats on the wings which, it was thought, would inadvertently open during aerobatics, possibly leading to crashes. This was later proven true in combat situations and aerobatic testing by various countries' test establishments. The leading edge slats and ailerons would flutter rapidly in fast tight turns, making targeting and control difficult, and eventually putting the aircraft into a stall condition.

The Heinkel He 112, based on a scaled-down Blitz, was the favorite of the Luftwaffe leaders. Positive aspects of the He 112 included the wide track and robustness of the undercarriage (this opened outwards from mid wing, as opposed to the 109s which opened from the wing root), considerably better visibility from the cockpit, and a lower wing loading that made for easier landings. Compared with the Bf 109, it was also cheaper. In addition, the V4 had a single-piece, clear-view, sliding cockpit canopy and a more powerful Jumo 210Da engine with a modified exhaust system. However, the He 112 was structurally complicated, being some 18% heavier than the Bf 109. It soon became clear that the thick wing, which spanned 12.6 m (41 ft. 4 in) with an area of 23.2 m<sup>2</sup> (249.7 ft<sup>2</sup>) on the first prototype (V1), was a disadvantage for a light fighter, decreasing the aircraft's rate of roll and maneuverability. As a result, the He 112 V4 which was used for the trials had new wings, spanning 11.5 m (37 ft. 8.75 in) with an area of 21.6 m<sup>2</sup> (232.5 ft<sup>2</sup>). However, the improvements had not been fully tested and the He 112 V4 could not be demonstrated in accordance with the rules laid down by the Acceptance Commission, placing it at a distinct disadvantage.

Because of its smaller, lighter airframe, the Bf 109 was 30 km/h (20 mph) faster than the He 112 in level flight, and superior in climbing and diving. The Commission ultimately ruled in favor of the Bf 109 because of the Messerschmitt test pilot's demonstration of the 109's capabilities during a series of spins, dives, flick rolls and tight turns, throughout which the pilot was in complete control of the aircraft.



**Figure 10: He 112 D**

Spin recovery was a very important part of the flight testing. At the time, pressurized cockpits did not exist. Oxygen apparatuses of the era were also far from perfect, so loss of oxygen and the danger of aeroembolism was very real. At the same time, it was already clear that aerial combat was about to move to increasingly higher altitudes, so performance at or above 10,000 meters (30,000 ft) was considered important. In the event of oxygen failure and loss of consciousness, a fighter would need to be stable enough to spin through multiple revolutions as the pilot regained consciousness in denser air, and still allow spin recovery. During acceptance trials, the 109 prototype was taken through 21 revolutions to the right, and 17 to the left, allowing successful recovery. The 109 made a favorable impression, while the He 112 appeared to fail in the same regard when its test pilot had to bail out after being unable to recover from a spin.

Many test pilots were allowed to swap prototypes at will, gaining experience with all competing designs. According to Dr. Hermann Wurster, a test pilot with the DVL (Deutsche Versuchsanstalt für Luftfahrt or German Research Institute for Aviation), the Bf 109 had lighter controls and a superior roll rate which made it better at aerobatics. The Bf 109 was not as easy to stall due to the leading-edge slats. Wurster also preferred 109's narrow track to the 112's wider undercarriage, thinking it was more suited to poor landing conditions. The 109 could land on one leg with battle damage or in an emergency, while the He 112 could not. Finally, the 109 was easier to produce and maintain than the He 112. The opinions were steadily shifting towards Willy Messerschmitt's design.

In March, the RLM received news that the British Supermarine Spitfire had been ordered into production. It was felt that a quick decision was needed in order to get the winning design into production as soon as possible, so on 12 March the RLM announced the results of the competition in a document entitled Bf 109 Priority Procurement, which ordered the Bf 109 into production. At the same time, Heinkel was instructed to radically re-design the He 112. The Messerschmitt 109 made its public debut during the 1936 Berlin Olympics, when the V1 prototype was flown.

## Designation

Originally the aircraft was designated as Bf 109 by the RLM, since the design was submitted by the Bayerische Flugzeugwerke ("Bavarian Aircraft Works") during 1935. BFW was renamed Messerschmitt AG after 11 July 1938 when Erhard Milch finally allowed Willy Messerschmitt to acquire the company. All Messerschmitt aircraft that originated after that date, such as the Me 210, were to carry the "Me" designation. Despite regulations by the RLM, wartime documents from Messerschmitt AG, RLM and Luftwaffe loss and strength reports continued to use both designations, sometimes even on the same page.

All extant airframes bear the official "Bf 109" designation on their identification plates, including the final K-4 models, with the notable exception of aircraft either initially built or re-fitted by Erla Maschinenwerk at Leipzig, which sometimes bear the erroneous Me 109 stamping.

The aircraft was given several nicknames by its operators and opponents, generally derived from the name of the manufacturer (Messer, Mersu, Messzer etc.), or the external appearance of the aircraft: the G-6 variant was nicknamed by Luftwaffe personnel as Die Beule ("the bump/bulge") because of the cowling's characteristic, bulging covers for the breeches of the 13 mm (.51 in) MG 131 machine guns, with the separate Beule covers eliminated by the time of the G-10 model's introduction of a subtly reshaped upper cowling, while Soviet aviators nicknamed it Hudoi, or "the skinny one" for its sleek appearance (compared to the more robust Fw 190). The names "Anton", "Berta", "Caesar", "Dora", "Emil", "Friedrich", "Gustav" and "Kurfürst" were derived from the variant's official letter designation (e.g. Bf 109G – "Gustav"), based on the German spelling alphabet of World War II, a practice that was also used for other German aircraft designs.

## Variants

When the Bf 109 was designed in 1934 by a team led by Willy Messerschmitt and Robert Lusser, its primary role was that of a high-speed, short range interceptor. It utilized the most advanced aerodynamics of the time and embodied advanced structural design which was ahead of its contemporaries. In the years of the Blitzkrieg, the Bf 109 was the only single-engine fighter operated by the Luftwaffe, until the appearance of the Fw 190.

The 109 remained in production from 1937 through 1945 in many different variants and sub-variants. The primary engines used were the Daimler-Benz DB 601 and DB 605, though the Junkers Jumo 210 powered most of the pre-war variants. The most-produced Bf 109 model was the 109G series (more than a third of all 109s built were the G-6 series, some 12,000 units being manufactured from March 1943 until the end of the war).



**Figure 11: Bf 109 B**

The initial production models of the A, B, C and D series were powered by the relatively low-powered, 670–700 PS (660-690 HP) Junkers Jumo 210 series engines. A handful of prototypes of these early aircraft were converted to use the more powerful DB 600.



**Figure 12: Bf 109 D**

When it was discovered in 1937 that the RAF was planning eight-gun batteries for its new Hawker Hurricane and Supermarine Spitfire fighters, it was decided that the Bf 109 should be more heavily

armed. The problem was that the only place available to mount additional guns was in the wings. There was only one spot available in each wing, between the wheel well and slats and there was room for only one gun, either a 7.92 mm MG 17 machine gun, or a 20 mm MG FF or MG FF/M cannon.

The first version of the 109 to have wing guns was the C-1, which had one MG 17 in each wing. To avoid redesigning the wing to accommodate large ammunition boxes and access hatches, an unusual ammunition feed was devised whereby a continuous belt holding 500 rounds was fed along chutes out to the wing tip, around a roller and then back along the wing, forward and beneath the gun breech, to the wing root where it coursed around another roller and back to the weapon.

From the 109F-series onwards, guns were no longer carried inside the wings. (A noteworthy exception was Adolf Galland's field-modified Bf 109 F-2, which had a 20 mm MG FF/M installed internally in each wing.) Only some of the projected 109K-series models, such as the K-6, were designed to carry 30 mm (1.18 in) MK 108 cannons in the wings.

In place of internal wing armament, additional firepower was provided through a pair of 20 mm MG 151/20 cannons installed in conformal gun pods under the wings. Although the additional armament increased the fighter's potency as a bomber destroyer, it had an adverse effect on the handling qualities, reducing its performance in fighter-versus-fighter combat and accentuating the tendency of the fighter to swing pendulum-fashion in flight. The conformal gun pods, exclusive of ammunition, weighed 135 kg (298 lb.); and 135 to 145 rounds were provided per gun.



**Figure 13: Bf 109 E-4**

The first major redesign came with the E series, including the naval variant, the Bf 109T (T standing for Träger, or carrier). The T variant never evolved beyond the initial design phase, as Germany never got close to having an operational aircraft carrier. The Bf 109E, or "Emil", introduced a number of structural changes in order to accommodate the heavier, but significantly more powerful 1,100 PS (1,085 HP) Daimler-Benz DB 601 engine, heavier armament and increased fuel capacity. Later variants of the Es introduced a fuselage bomb rack or provision for a long-range drop-tank, and used the DB 601N engine of higher power output. The 109E first saw service with the "Condor Legion" during the last phase of the Spanish Civil War and was the main variant from the beginning of World War II until mid-1941 when the 109F replaced it in the pure fighter role. (Eight 109Es were

assembled in Switzerland in 1946 by the Dornier-Werke, using license built airframes; a ninth airframe was assembled using spare parts.)



**Figure 14: Bf 109 F-4**

The second major redesign during 1939–40 gave birth to the F series. The "Friedrich" saw a complete redesign of the wings with rounded tips for better flight handling; the cowling was blended in with a spinner, reducing drag; radiator housing was greatly improved in its aerodynamics, elevator braces were removed; fuel tank capacity was increased, armament improved, and armor added. The Friedrich was powered by the 1,175 PS (1,159 HP) DB 601N (F-1, F-2) or the 1,350 PS (1,332 HP) DB 601E (F-3, F-4). Considered by many as the high-water mark of Bf 109 development, the F series abandoned the wing cannon and concentrated all armament in the forward fuselage with a pair of synchronized machine guns above and a single 15 or 20mm Motorkanone-mount cannon behind the engine, the latter firing between the cylinder banks and through the propeller hub. This configuration was used by all subsequent variants. A handful of Bf 109Fs were used late in the Battle of Britain in 1940, but the variant only came into wide use in the first half of 1941.

Fighters with liquid cooled engines were vulnerable to hits in the cooling system. For this reason, on later Bf 109 F, G and K models the two coolant radiators were equipped with a cut-off system. If one radiator leaked, it was possible to fly on the second, or to fly for at least five minutes with both closed.



**Figure 15: Bf 109 G-10**

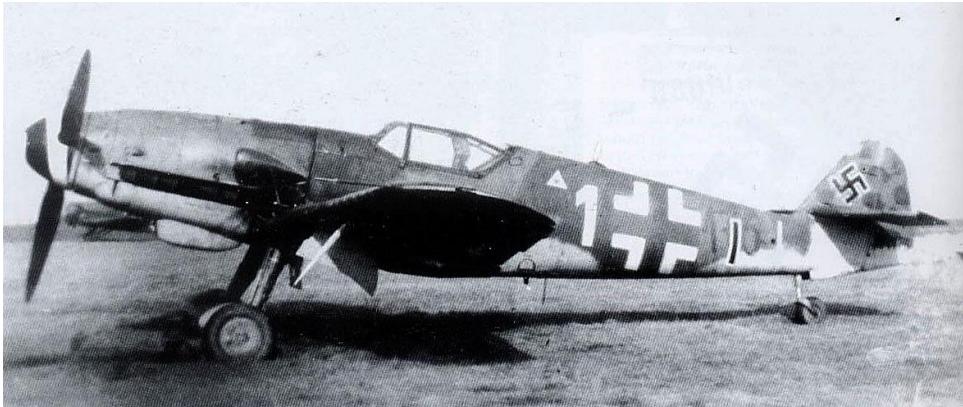
The G series, or "Gustav", was introduced in mid-1942. Its initial variants (G-1 through G-4) differed only in minor details from the Bf 109F, most notably in the more powerful 1475 PS (1,455 HP) DB 605 engine. Odd numbered variants were built as high-altitude fighters with a pressurized cockpit and GM-1 boost, while even numbered variants were non-pressurized, air superiority fighters and fighter-bombers. Long-range photo-reconnaissance variants also existed. The later G series (G-5 through G-14) was produced in a multitude of variants, with uprated armament and provision for a number of kits of pre-packaged, generally factory-installed parts known as Umrüst-Bausätze (usually contracted to Umbau) and adding a "/U" suffix to the aircraft designation when installed. Field kits known as Rüstsätze were also available for the G-series, but those did not change the aircraft designation. A lot of effort also went into simplifying the manufacturing process. Build time for the fuselage for the G variant was only 163 hours, compared to already record-breaking 203 for the earlier variants.

By early 1944 tactical requirements resulted in the addition of MW-50 water injection boost and high-performance superchargers, boosting engine output to 1,800–2,000 PS (1,775-1,973 HP). From early 1944 a number of G-2s, G-3s, G-4s and G-6s were converted to two seat trainers, known as the G-12. An instructor's cockpit was added behind the original cockpit and both were covered by an elongated, glazed canopy. The Rüstsätze field modification kits and Umrüst-Bausätze factory conversion kits were part of a system promulgated by the RLM as a whole, throughout the German military aviation industry, with each airframe type number having its own set of "/R" and/or "/U" numbered designations for such upgrade packages.

## K for Kurfürst

The Bf 109 K was the last of the series to see operational duty and the last in the Bf 109 evolutionary line. The K series was a response to the bewildering array of series, models, modification kits and factory conversions for the Bf 109, which made production and maintenance complicated and costly –

something Germany could ill-afford late in the war. The RLM ordered Messerschmitt to rationalize production of the Bf 109, consolidating parts, types, and so on, to produce a uniform, standard model with better interchangeability of parts and equipment. At the same time, the existing flaws of the design were to be remedied. Work on the new version began in the spring of 1943, and the prototype was ready by the autumn of that year. Series production started in August 1944 with the K-4 model, due to changes in the design and delays with the new DB 605D powerplant. The K-4 was the only version to be mass-produced.



**Figure 16: Bf 109 K-4**

Externally the K series could be identified by changes in the locations of the radio equipment hatch, which was moved forward and to a higher position between frames four and five, and the filler point for the fuselage fuel tank, which was moved forward to a location between frames two and three. In addition, the D/F loop was moved aft to sit between frames three and four on the top fuselage spine and a small circular plate above the footstep on the port side of the fuselage was deleted. The rudder was fitted as standard with a Flettner tab and two fixed tabs although some rare examples were not fitted with the fixed tabs. All K-4s were to be fitted with a long retractable tailwheel (350 × 135 mm/14 × 5 in) with two small clamshell doors covering the recess when the tail-wheel was retracted.

The wings featured the large rectangular fairings for the large 660 × 190 mm (26 × 7 in) main wheels. Small wheel well doors, originally planned for the G series, were fitted to the outer ends of the wheel bays, covering the outer wheels when retracted. These doors were often removed by front-line units. The radio equipment was the FuG 16ZY with an antenna mast fitted under the port outer wing and FuG 25a IFF as well as the FuG 125 Hermine D/F equipment. Internally, the oxygen bottles were relocated from the rear fuselage to the right wing. Flettner tabs for the ailerons were also to be fitted to serial production aircraft to reduce control forces, but were extremely rare, with the majority of the K-4s using the same aileron system as the G series.

Armament of the K-4 consisted of a 30 mm (1.18 in) MK 108 engine-mounted cannon (Motorkanone) with 65 rounds, and two 13 mm (.51 in) MG 131s in the nose with 300 RPG although some K-4s were fitted with the MG 151/20 as the Motorkanone. Additional Rüstsätze, or equipment kits, such as a 300 L (80 US gal) drop tank (R III), bombs up to the size of 500 kg/1,100 lb. (R I), underwing 20 mm Mauser MG 151/20 cannon gondola pods (R IV) or 21 cm (8 in) Wfr.Gr. 21 rockets (as on the Gustav models) could be carried after minimal preparations; the latter two however were rarely used

by Bf 109 units at this stage of the war, although III./JG 26 were almost completely equipped with K-4s which were fitted with R IV:

*...apparently all of the K-4s supplied to III./JG 26 were also equipped with 20 mm-guns in the hated underwing tubs. Uffz. Georg Genth's regular aircraft was a G-10, but on occasion he flew a K-4. He preferred the G-10 as a dogfighter, as the K-4's bulky armament sharply reduced its maneuverability.*

In addition there were problems with the 30 mm (1.18 in) MK 108 Motorkanone, which often jammed while the aircraft was maneuvering in battle, leaving the pilot to fight on with the two heavy machine guns. The standard Revi 16B reflector sight was fitted, which was slated to be replaced later by the REVI 16B Gyro gunsight, although this never happened.

Power was provided in production K-4s by a Daimler-Benz DB 605 DB or DC engine (very early K-4s used the earlier DM). The DB could use B4 fuel which, with MW 50 Methanol Water injection equipment, generated an emergency power rating of 1,600 PS at 6,000 m (1,160 PS maximum continual at 6,600 m), and take-off power of 1,850 PS at 0 m, with a maximum supercharger boost of 1.8 ATA. The DB could also be run on higher octane C3 fuel, but use of MW 50 was forbidden. The DC, which was reinforced internally, could also run on B4 or C3 fuel and could generate a potential 2,000 PS, but only when using C3 fuel with MW 50 and a boost of 1.98 ata, otherwise the power rating was similar to that of the DB. A wide-chord, three bladed VDM 9-12159A propeller of 3 m diameter was used, as on the G-6/AS, G-14/AS and G-10.

Deliveries began in mid-October 1944. 534 examples had been delivered by the Messerschmitt A.G., Regensburg by the end of November 1944, and 856 by the end of the year. Regensburg delivered a total of 1593 by the end of March 1945, after which production figures are missing. With such a high rate of production, despite continuous heavy fighting, by the end of January 1945 314 K-4s – about every fourth 109 – were listed on hand with the first line Luftwaffe units. Ultimately it was intended to equip all Bf 109 units with the 109K, which marked the final stage of 109 development before the jet age.

Using MW 50 and maximum boost the Bf 109 K-4 was the fastest 109 of World War II, reaching a maximum speed of 710 km/h (440 mph) at 7,500 m (24,610 ft.) altitude. Without MW 50 and using 1.80 ATA the K-4 reached 670 km/h (416 mph) at 9,000 m (26,528 ft.). The Initial Rate of climb was 2,775 ft. (850 m)/min, without MW 50, and 3,563 ft. (1,090 m)/min, using MW 50.

The Bf 109 remained comparable to opposing fighters until the end of the war. However, the deteriorating ability of the thousands of novice Luftwaffe pilots by this stage of the war meant the 109's strengths were of little value against the numerous and well-trained Allied fighter pilots.

# AIRCRAFT OVERVIEW



# AIRCRAFT OVERVIEW

## General Description

The Messerschmitt Bf 109 K-4 fighter aircraft is a single-seat, low wing monoplane powered by a 12-cylinder liquid-cooled supercharged inverted Vee Daimler-Benz DB 605 piston engine. The engine is equipped with a one-stage centrifugal supercharger with a MW-50 injection into the supercharger intake. The engine spins a three blade constant speed propeller.

The powerplant consists of a Daimler-Benz DB 605 DB engine that delivers approximately 1,430 horsepower at 2,800 RPM at sea level. This could be further increased to 1850 horsepower by the use of MW-50 water-methanol injection. Maximum emergency power in level flight was 1,600 horsepower at 2,800 RPM at 6000 meters.

The oval light-metal monocoque Bf 109 fuselage is made of two mirrored halves joined longitudinally at top and bottom to a double-width longitudinal. Each of the two halves is built around longitudinal stringers connected to vertical panels. The panels are flush riveted for a smooth outer surface.

The low-wing cantilever monoplane wing of the Kurfürst has remained virtually unchanged through all variants of the venerable Messerschmitt fighter. The all-metal single-spar structure is covered with flush-riveted stressed metal skin.

The all-metal tail unit contains both the tail unit and the vertical stabilizer. It is attached to the rear fuselage attachment bulkhead.

The armament consists of a 30 mm (1.18 in) MK 108 engine-mounted cannon (Motorkanone) with 65 rounds, and two 13 mm (.51 in) MG 131s in the nose with 300 rounds per gun.

Specifications for the Bf 109 K-4 are:

- Wingspan – 9.92 m
- Overall length – 9.02 m
- Height (tail down) – 2.35 m
- Empty weight – 2,800 kg
- Loaded weight – 3,362 kg
- Wing area – 16.08 m<sup>2</sup>

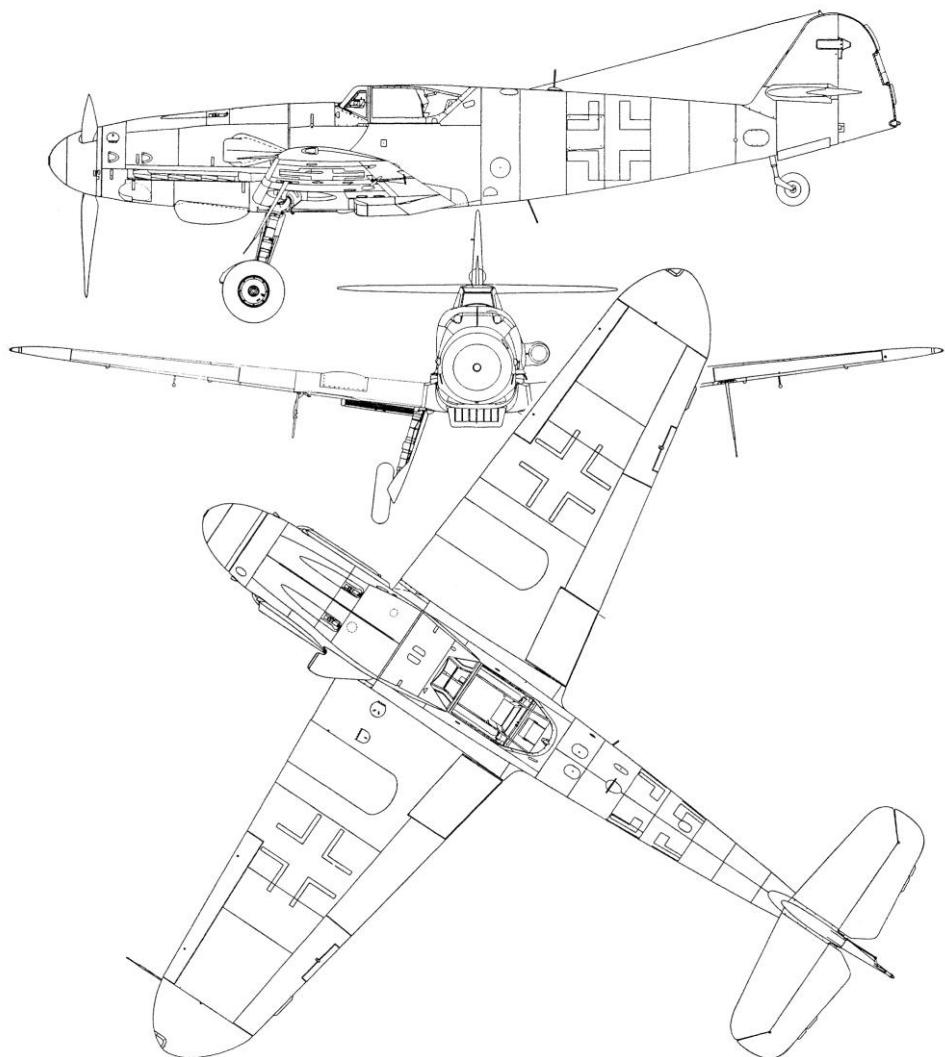
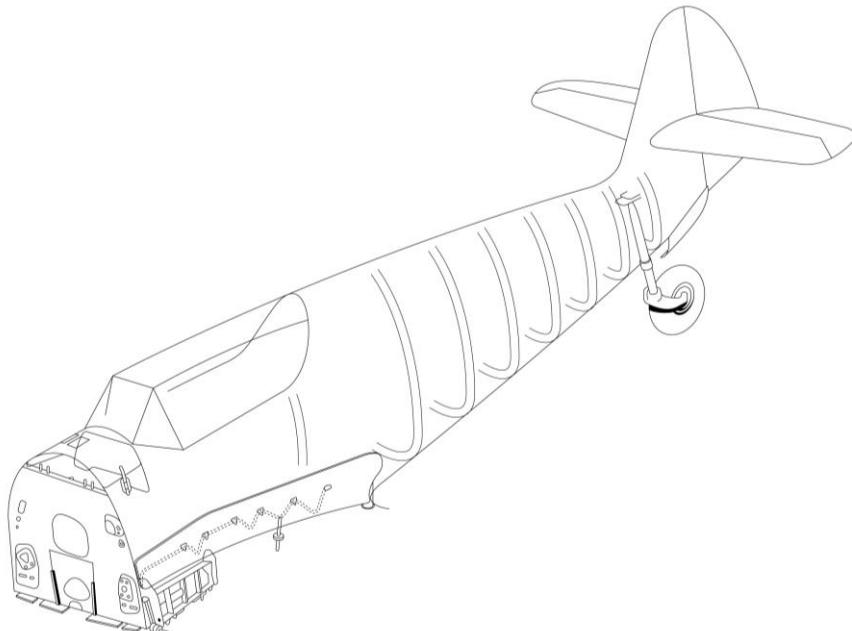


Figure 17: Bf 109 K-4 Drawings

## Fuselage

The oval light-metal monocoque Bf 109 fuselage is made of two mirrored halves joined longitudinally at top and bottom to a double-width longitudinal. Each of the two halves is built around longitudinal stringers connected to vertical panels. The panels are flush riveted for a smooth outer surface.



**Figure 18: Bf 109 K-4 Fuselage**

Originally based on the early 1930s Bf 108 transport plane, the Bf 109 carries Messerschmitt's "lightweight construction" principles well into the 1940s. The desire to minimize the number of separate parts in the aircraft can be found in the use of two large, complex brackets which are fitted to the firewall. These brackets incorporate the lower engine mounts and landing gear pivot point into one unit. A large forging attached to the firewall houses the main spar pick-up points, and carries most of the wing loads. By concentrating the loads in the firewall, the structure of the Bf 109 can be made relatively light and uncomplicated.

One advantage of this design is the fact that the main landing gear, which retracts through an 85-degree angle, is attached to the fuselage, making it possible to completely remove the wings for servicing without additional equipment to support the fuselage. This also simplifies the wing structure, since it does not have to bear the loads imposed during takeoff or landing.

Other design features carried over from the 108 include automatically-opening leading edge slats and the enclosed canopy.

The fuselage aft of the engine firewall went through relatively few changes from 1933 to 1945. Early variants remained similar to the initial V prototypes. Bf 109 D-1 had the structure somewhat strengthened by increasing the thickness of the stringers and the panels and strengthening the landing gear legs.

By early 1940 various small changes had accumulated to a significant overall weight increase, which had a negative effect on performance. The F for Friedrich variant had many small aerodynamic improvements that streamlined the structure.

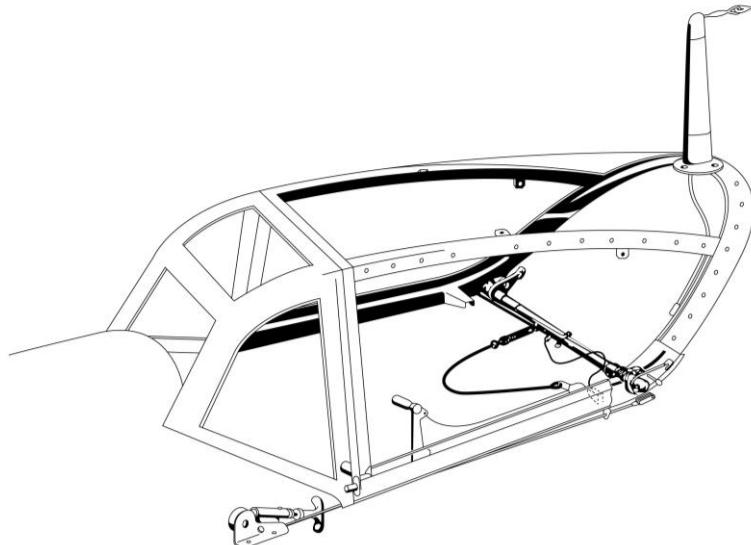
The fuselage remained largely unchanged for the G series, with some variants using a wooden tail section instead of the all-metal one due to strained supply situation in total war conditions.

By September of 1944, first Bf 109 Ks were beginning to roll off the production line. Largely based on the stopgap Bf 109 G-14, the K-0 had a larger engine cowling. The radio equipment hatch was moved forward and to a higher position between frames four and five, and the filler point for the fuselage fuel tank was moved forward to a location between frames two and three.

In addition, the D/F loop was moved aft to sit between frames three and four on the top fuselage spine and a small circular plate above the footstep on the port side of the fuselage was deleted.

## Canopy

The canopy on the 109 had perhaps gone through more changes and modifications than any other part of the aircraft, save the engine. While the aircraft has always been committed to the enclosed canopy idea, the original early 1930s design featured poor rearwards visibility, and the fact that it opened sideways made landings and taxi a harrowing affair.



**Figure 19: Bf 109 K-4 Erla or "Galland" Canopy**

Attempts to reduce interference drag also made the canopy sit rather low over the engine cowling, making the cockpit extremely cramped for taller pilots. At the same time, having very limited head space meant keeping all variants of the 109 extremely potent in a dive, with reduced drag enabling the aircraft to escape from virtually any pursuer.

The G series of the 109 was the first to feature pressurized cockpits. This led to another canopy redesign, featuring a more complex canopy framework.

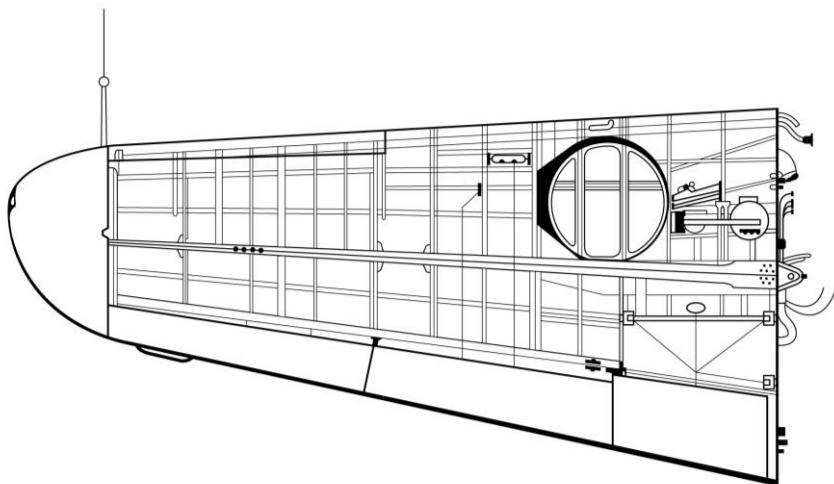
The K series are fitted with the clear Erla canopy, often mislabeled "Galland hood", that features a bulge that increases overall visibility while removing most of the older "greenhouse canopy" framework.

## Wing

The 109 features a low-wing cantilever monoplane wing, virtually unchanged through all variants. The all-metal single-spar structure is covered with flush-riveted stressed metal skin.

Another example of the Bf 109's advanced design is its use of a single, I-beam main spar in the wing, positioned more aft than usual (to give enough room for the retracted wheel), thus forming a stiff D-shaped torsion box. The wing profile is NACA 2R1 14.2 at the root and NACA 2R1 11.35 at the tip, with a thickness to chord ratio of 14.2% at the root and 11.35% at the tip.

The wing of the 109 is made with no washout, i.e. with the same angle from wing root to wingtip. Most Allied fighters of the time were designed with the angle of incidence greater at the wing root and decreasing across the span, becoming lowest at the wing tip. This gives the 109's wing increased lift compared to similar Allied fighters, while the tip stalling problem normally solved by washout on other designs is solved on the 109 with the use of automatic leading-edge slats that normally extend before the wingtip can stall. The overall result is an excellent high-lift wing that is also difficult to stall.



**Figure 20: Bf 109 K-4 Wing**

Each wing is attached to the fuselage at two points on the single spar and a third at the leading edge, the latter transmitting torsional loads. The wing features an innovative hinged trailing edge, with the outer portions functioning as ailerons and the inner portions as flaps.

A large panel under the wing center section can be removed to gain access to the L-shaped main fuel tank, which is situated partly under the cockpit floor and partly behind the rear cockpit bulkhead. Other, smaller panels give easy access to the cooling system and electrical equipment.

Another major design feature that separates the 109 from competitors from the start is its smaller wing area with higher wing loading. It gives the Messerschmitt fighter the high speed it is famed for at the cost of decreased low-speed control. A smaller wing requires more airflow to generate enough lift to maintain flight. To compensate for this, the Bf 109 includes advanced high-lift devices on the wings, including automatically-opening leading edge slats, and fairly large camber-changing flaps on the trailing edge. The slats increase the lift of the wing considerably when deployed, greatly improving horizontal maneuverability. The 109 also includes ailerons that droop when the flaps are

lowered, thereby increasing effective flap area. When deployed, these devices effectively increase the wings' coefficient of lift.

Most changes to the wings throughout the 109's history were limited to its aerodynamic weak spot, the wing radiators. The airflow-disrupting structures were eventually partially recessed into the wing for the F series. Other attempts to improve aerodynamics included changes to the leading-edge slat area, and modifying aileron and flap design.

The wings on the K-4 feature the large rectangular fairings for the large 660 x 190 mm main wheels. Small wheel well doors, originally planned for the G series, are fitted to the outer ends of the wheel bays, covering the outer wheels when retracted. These doors are often removed by front-line units.

## Tail Section

The Bf 109 K-4 features an all-metal tail unit that contains both the tail unit and the vertical stabilizer. It is attached to the rear fuselage attachment bulkhead.

The main load-bearing section of the vertical stabilizer is a diagonal spar, to which the all-metal horizontal stabilizer and the tailwheel assembly are attached.

The fabric-covered rudder contains a metal frame with a spar and seven ribs. It has both aerodynamic horn balancing and mass balancing. There is also a trim tab; due to the aircraft being generally very stable in flight, the trim tab is only adjustable on the ground.

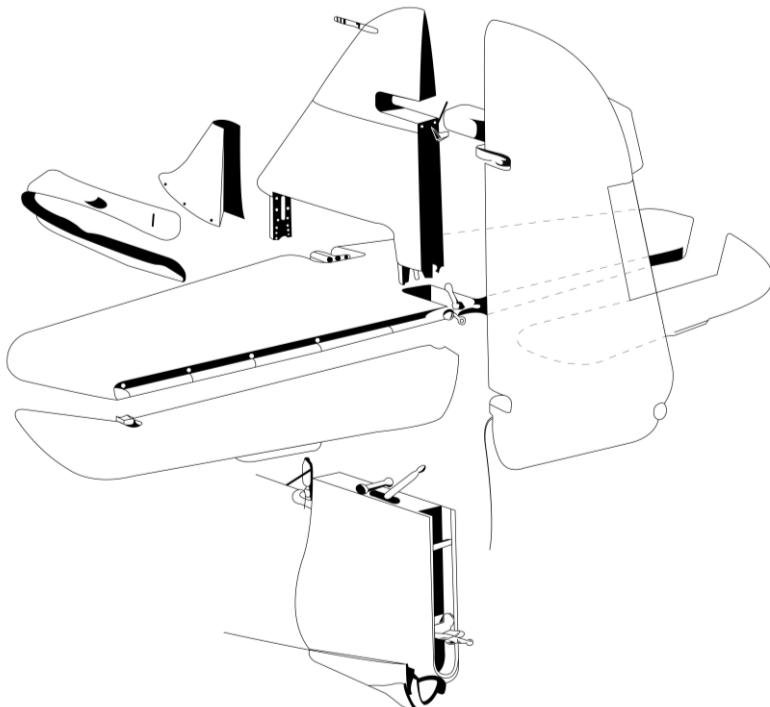


Figure 21: Bf 109 K-4 Tail Section

## Flight Controls

The control unit assembly consists of the horizontal stabilizer and elevators, the vertical stabilizer and rudder, the ailerons, and the flaps.

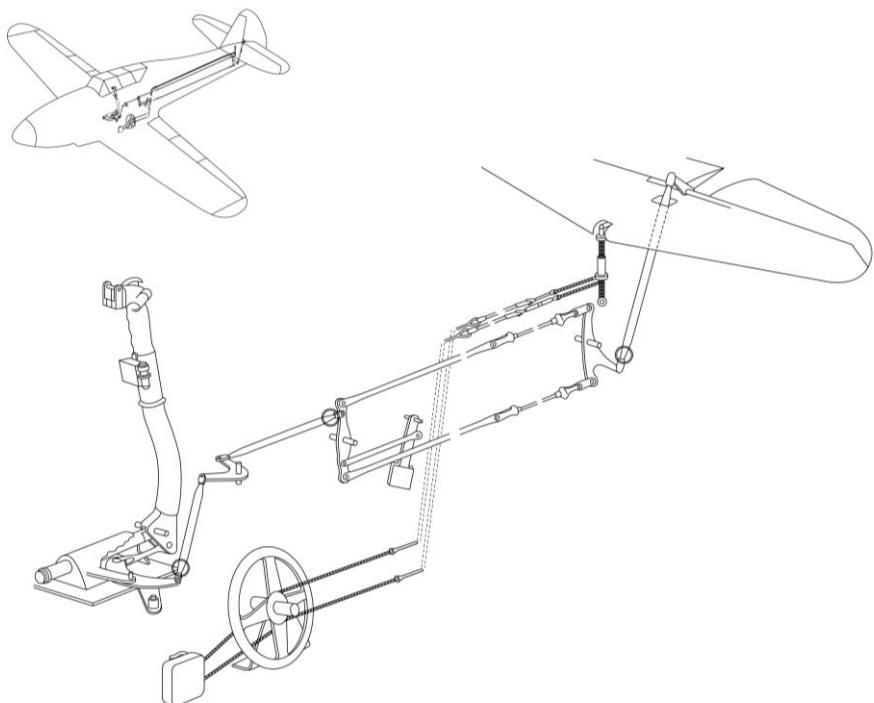
The Bf 109 K-4 has a conventional control scheme with surfaces that include a vertical stabilizer, rudder, horizontal stabilizer, two elevators, two ailerons, and flaps.

The table below shows all control surfaces with their potential ranges of motion:

Control			Position
<b>Adjustable Horizontal Stabilizer</b>	0-Position		0°
	+ Position		+1°10'
	- Position		-6°
<b>Elevator Deflection</b>	Hor Stab Trim 0"	pull	27°
		push	24°
	Hor Stab Trim +1° 10'	pull	26°
		push	25°
	Hor Stab Trim -6°	pull	30°
		push	21°
<b>Rudder Deflection</b>			32°
<b>Rudder Flettner</b>			32°
<b>Aileron Deflection</b>	up	22°40'	
	down	11°20'	
<b>Camber Flaps</b>	0-Position	0°	
	extended	40°	
<b>Wing Incidence Angle</b>	At Rib 1, 7 and 13		1°42'

The flight stick can be moved forwards and backwards in conventional fashion to control the elevator. The stick can be moved 15°30' forwards and 15°30' backwards.

As the entire tailplane can be trimmed in flight by using the Horizontal Stabilizer Trim Handwheel, elevator deflection depends on tailplane position. Please see the table above for details.



**Figure 22: Bf 109 K-4 Elevator Control Cables**

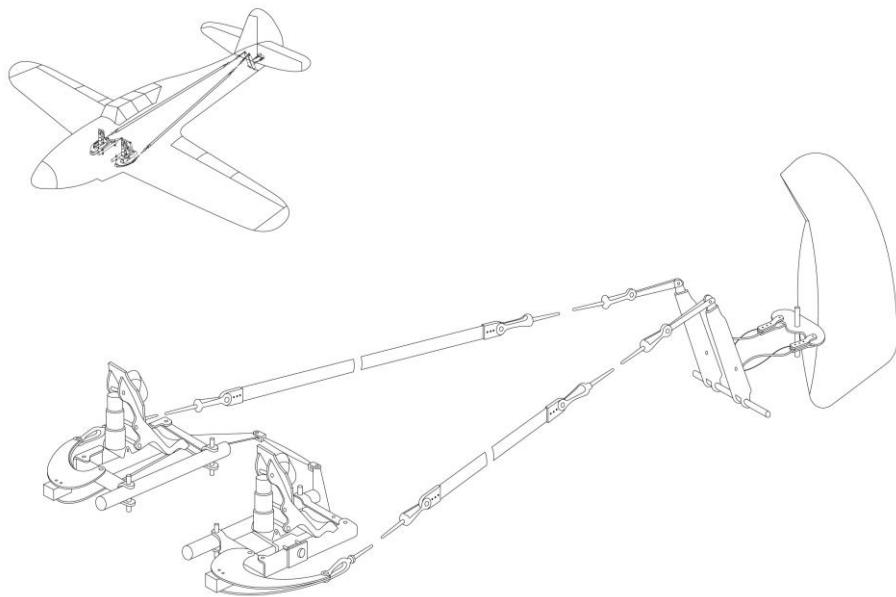
The flight stick can also be moved sideways to control the ailerons in conventional fashion.

Flap position is controlled via a handwheel located to the pilot's left. The flaps position scales are drawn on the root part of the flaps and are visible from the cockpit. Flaps can be deflected from 0 to 40°, with the 40° position reserved for landing, and 20° generally used for take off. One full turn of the flap handwheel is equal to roughly 5° of flap deflection; therefore four full turns are required for the Take-Off position, and eight full turns for Landing.

Tailplane position is controlled via a handwheel located to the pilot's left alongside the flap handwheel. A cockpit indicator is provided near the handwheel, with the round window on the mechanical indicator displaying the incidence level. Negative incidence is shown with a minus sign, e.g. -2.5, while positive incidence is shown with no sign, i.e. 1 means +1.

The tailplane can be moved from +1°10' to -6° degrees.

The 109 K series featured Flettner tabs on serial production aircraft to reduce control forces, but these were often not fitted to production examples, with many of the K-4s using the same aileron system as the G series. Some aircraft rolled off the production line with only ground-adjustable aileron Flettner trim, but no elevator trim, which resulted in uneven force distribution on the stick, making control more difficult at higher speeds.



**Figure 23: Bf 109 K-4 Rudder Control Cables**

The pilot opinion on 109's controls differs greatly. German pilots generally swore by it, and found the 109 a real pleasure to pilot. Allied test pilots, conversely, found the 109 difficult to control and reported that at high speeds control forces required to effectively maneuver were just too great. The difference in opinion probably has to do with what the pilots on each side were used to. Allied pilots were used to light control forces on aircraft with boosted controls, so to them the 109 was unusually heavy, and the change was clearly not for the better. Conversely, German pilots were not used to the luxuries of boosted controls and trained accordingly. To them, the greater control forces were the norm. Many found the experience invigorating. In either case, the 109 certainly requires quite a bit of muscle from the pilot to maneuver.

The aircraft is generally easy to pilot when proper control forces are applied. However, the tendency of the left wing to suddenly drop on take-off and landing is the aircraft's Achilles heel. Precise rudder input is required to counter the yaw.

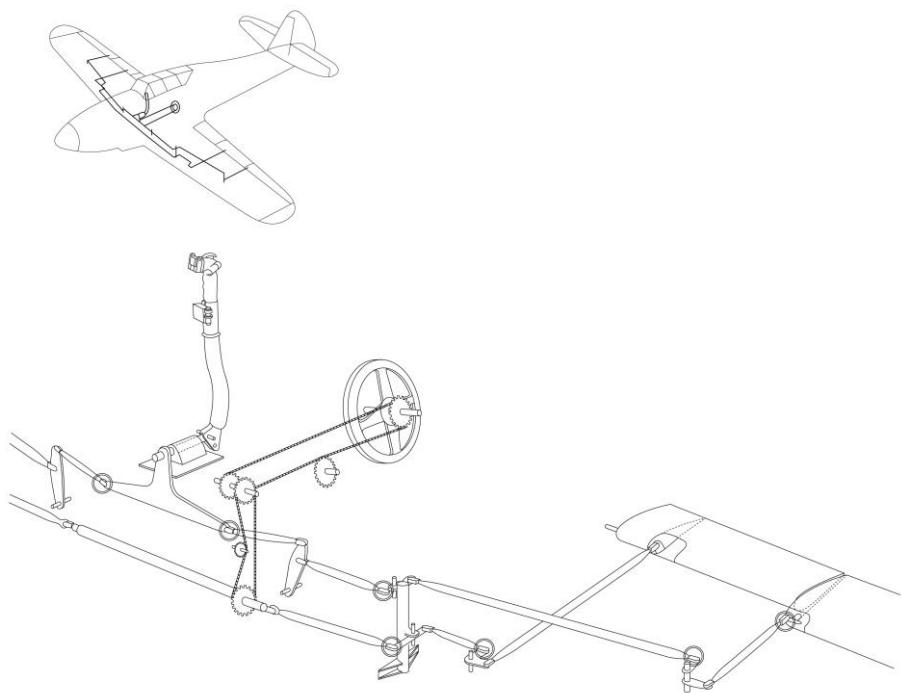
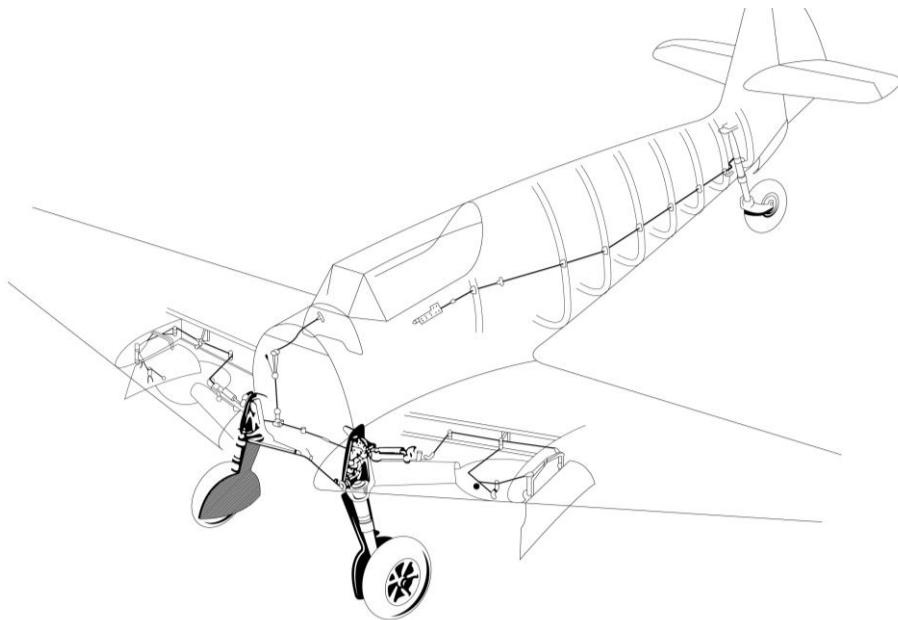


Figure 24: Bf 109 K-4 Aileron Control Cables

## Landing Gear

The Bf 109 features retractable narrow-track landing gear. Wheels are raised and lowered hydraulically. There is also an auxiliary manual system for operating the gear.



**Figure 25: Bf 109 K-4 Landing Gear**

The tailwheel on the 109 went through many changes. While many earlier variants featured a fixed tailwheel, the K-4 reintroduces the retractable type that improves high-speed performance. The tailwheel also features two small clamshell doors covering the recess when the tail-wheel was retracted.

The undercarriage is controlled by simple pushbuttons located on the cockpit's left-hand side.

To raise the landing gear, simply depress the corresponding "Ein" (German for "on" or "in") button and wait for the operation to complete. Once the gear is locked in position, red lights illuminate on the undercarriage indicator unit.

To lower the landing gear, depress the corresponding "Aus" (German for "off" or "out") button and wait for the operation to complete. Once the gear is fully extended, green lights illuminate on the undercarriage indicator unit.

In case of hydraulics failure, the main gear can also be lowered by pulling the emergency gear extension handle. This unlocks the shock struts which can then extend with the help of gravity.

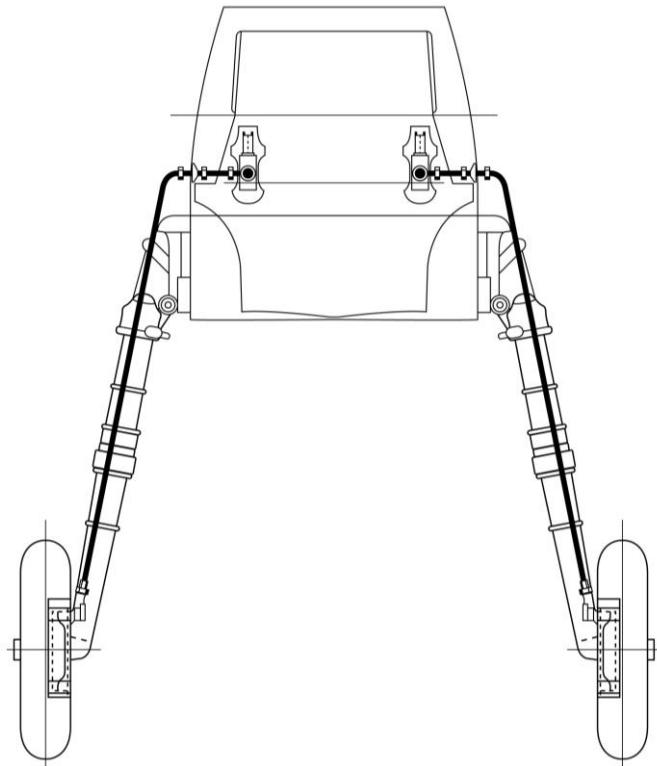
The tailwheel is retracted simultaneously with the main gear.

The free-wheeling tailwheel strut can be locked or unlocked via a control rod located by the pilot's left elbow.

## Brake System

The Bf 109 K-4 has hydraulically operated brake shoes on each of the two main wheels. Each has its own hydraulic booster and brake lines. Each wheel can be braked individually.

The entire system is conventionally operated via rudder pedals.



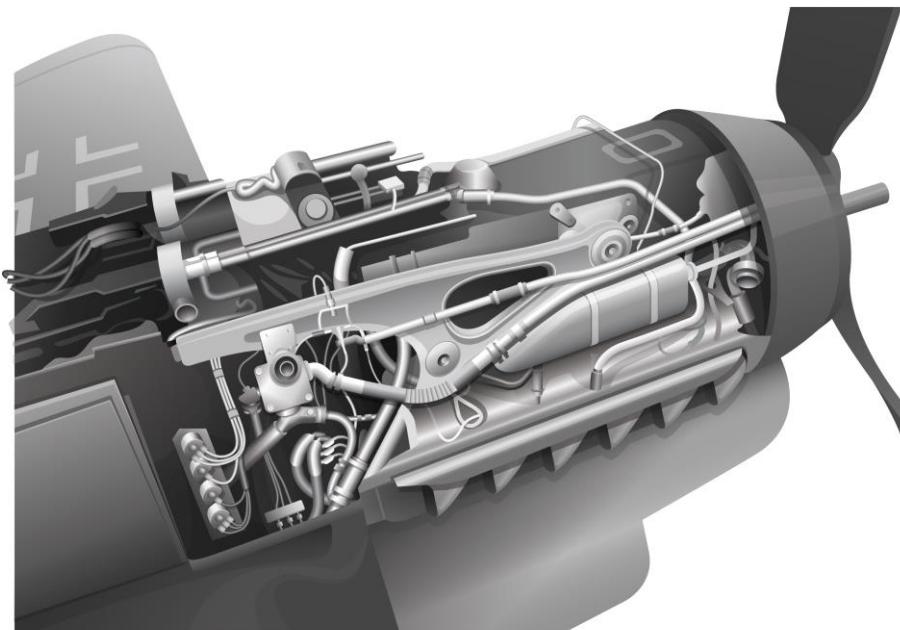
**Figure 26: Bf 109 K-4 Brake System**

## Engine

Most of the Bf 109s were powered by various variants of the Daimler-Benz DB 601 V12 engine or its derivative, the DB 605. Same is the case for the Bf 109 K-4.

Engine supply situation has often been a weak spot for the German aircraft industry, and it was especially felt in 1944 and 1945 as the 109K was in production. A variety of DB 605 variants were

installed on production K-4s. Initial plans to use the advanced DB 605L with a two-stage supercharger were foiled with a single lucky Allied bomb that took out a high-altitude test chamber, delaying 605L deliveries by nearly a year. As it is, production 109Ks shipped with DB 605B, DB 605DC or DB 605ASC, with some very late production K-4s finally receiving the DB 605L.

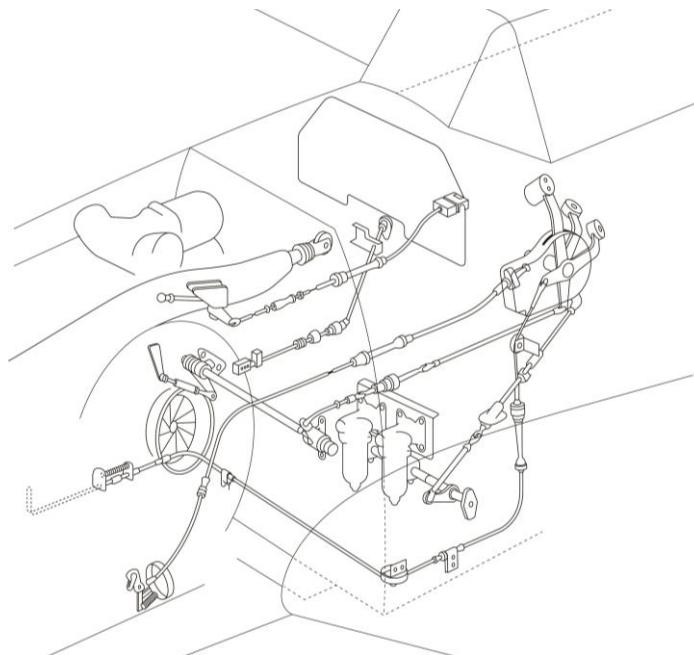


**Figure 27: Daimler-Benz DB 605**

Production K-4s were often powered by a Daimler-Benz DB 605DB or DC engine. The DB could use B4 fuel which, with MW 50 Methanol Water injection equipment, generated an emergency power rating of 1,600 PS at 6,000 m (1,160 PS maximum continual at 6,600 m), and take-off power of 1,850 PS at 0 m, with a maximum supercharger boost of 1.8 ATA. The DB could also be run on higher octane C3 fuel, but use of MW 50 was forbidden. The DC, which was reinforced internally, could also run on B4 or C3 fuel and could generate a potential 2,000 PS, but only when using C3 fuel with MW 50 and a boost of 1.98 ATA, otherwise the power rating was similar to that of the DB.

The DCS Bf 109 K-4 is modeled with the DB 605 DB engine.

The engine is held in two large, forged, magnesium alloy Y-shaped legs cantilevered from the firewall. Each of the legs is secured by two quick-release screw fittings on the firewall. All of the main pipe connections are color-coded and grouped in one place, where possible, and electrical equipment is plugged into junction boxes mounted on the firewall. The entire powerplant can be removed or replaced as a unit in a matter of minutes.



**Figure 28: Daimler-Benz DB 605 Controls Diagram**

From the inception of the design, priority was given to easy access to the powerplant, fuselage weapons and other systems while the aircraft was operating from forward airfields. To this end, the entire engine cowling is made up of large, easily removable panels which are secured by large toggle latches.

The engine replacement is one of the most incredible design innovations on the 109. It caused an absolute sensation when first reported to the press. US Marine Corps Major Al Williams, Schneider Trophy competitor, and a friend to some high-ranking German officials, flew an early pre-war D variant of the Bf 109 in 1938, some time before the war started. He wrote a glowing report, published in the US and widely republished across the world. It said, in part:

*I will give it to you point blank and let you estimate its value. The engine of the Messerschmitt can be removed, replaced with another - ready to go - inside of 12 minutes.*

*You can imagine the uproar of doubt and incredulity in official circles when I returned to the States and spread that word around. The reason for the uproar was quite obvious, in that in very many instances, between 24 and 36 hours were required to remove one engine and replace it with another in many of our standard types of fighting planes.*

Another large advantage of the Daimler-Benz engine is its direct fuel injection. While most Allied aircraft use complex and expensive turbo superchargers that require high-octane fuel, the DB 601 and its 603 and 605 derivatives could compete with them using low-grade 87-octane fuel due to the use of direct fuel injection.

**Engine Ratings:**

Operating Condition	RPM	ATA	Max Time
<b>WEP (MW-50)</b>	$2,800 \pm 50$	$1.75 \pm 0.01$	10 min
<b>Take-Off and WEP</b>	-	-	-
<b>Combat</b>	$2,600 \pm 50$	$1.35 \pm 0.01 *$	30 min
<b>Cruise</b>	$2,400 \pm 65$	$1.25 \pm 0.01$	Continuous
<b>Economy</b>	$2,000 \pm 80$	$1.05 \pm 0.01$	Continuous

\*) During climb boost pressure may be regulated by a further 0.03 ATA to between 1.31 and 1.39 ATA.

**Note: With the MW-50 system installed, normal Take-Off and Emergency Power is no longer attainable. Combat mode should be used instead.**

## Supercharger

The Daimler Benz DB 605 engine has a hydraulically driven single-stage supercharger, coupled with a MW-50 Water-Methanol injection.

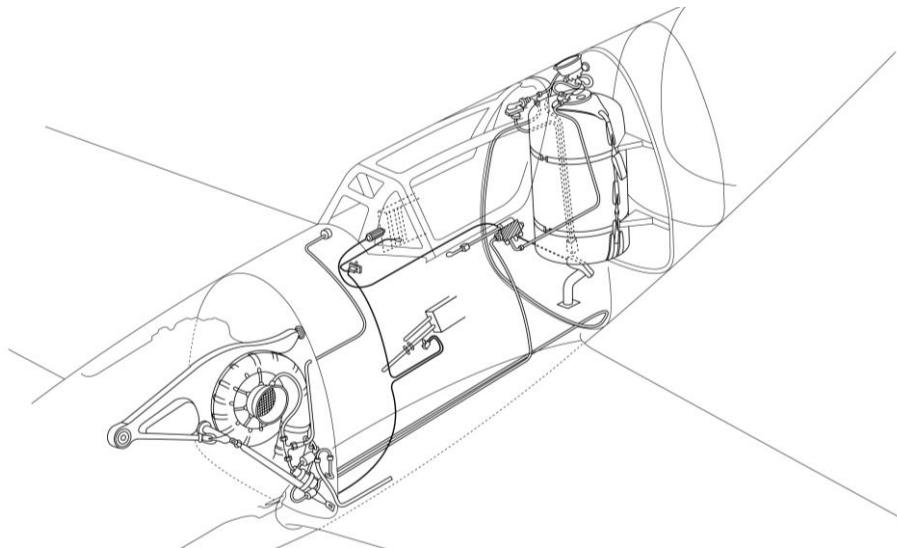


**Figure 29: Supercharger Pressure Gauge**

## MW-50 Water-Methanol Injection

MW-50 (MethanolWasser 50) is a 50-50 mixture of methanol and water sprayed into the Bf 109 K-4's supercharger, allowing the use of increased boost pressures.

Many Bf 109 variants use some sort of boost. The G-6 was the first variant designed for a new field modification kit or Rüstsatz model that allowed a large number of various standard kits to be quickly installed in the field, as well as a number of Umrüstsätze, or factory kits, which could be installed in the factory. The U2 kit provided for a 118-liter tank behind the cockpit used for the GM 1 nitrous oxide injection system, while the U3 kit used a tank for the MW 50 water-methanol mix.



**Figure 30: MW-50 System Diagram**

The primary effect of the mixture spray is its anti-detonant effect, which is how the increase in boost pressure is achieved.

The secondary effect of the mixture spray is cooling of the engine.

The boost increase provided by MW 50 can be described with the word "incredible".

Turning the system on immediately increases engine power by almost 100 HP due to the fact that a cooler engine can pull in more air. At the same time, turning on the MW-50 enables much higher supercharger boost levels. In optimal conditions, both effects combined increase engine power by a whopping 500 HP.

At sea level, the engine runs at over 1800 hp with MW-50 enabled, compared to 1430 hp with the MW-50 off.

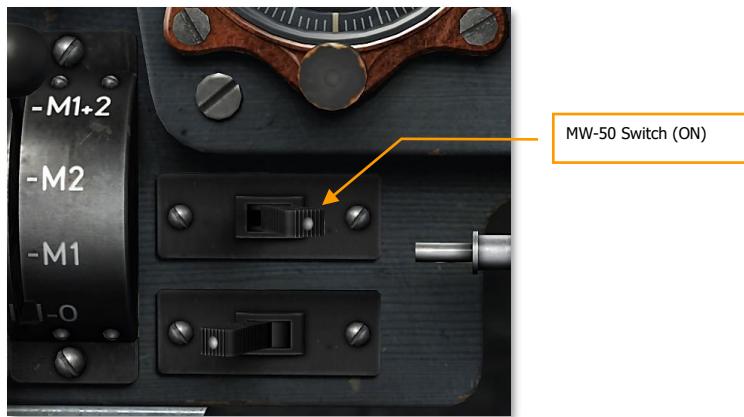
While the primary boost-increasing effects deteriorate with altitude, the secondary cooling effects are still noticeable. The MW-50 system can therefore be used to cool down the engine at all altitudes in an event of an emergency.

The boost provided by the MW-50 begins to decrease in power at altitudes above 6,000 meters.



**Figure 31: Water/Methanol Pressure Gauge**

Please note that the MW 50 tank can also be used to store conventional aviation fuel, in essence providing extra range at the expense of available extra power.



**Figure 32: MW-50 Switch**

The MW-B4 Selector on the left-hand side of the cockpit is used to set the MW 50 tank status. Please note that incorrectly setting this switch can have catastrophic results, by either feeding the water-methanol mixture into the fuel lines, or spraying aviation fuel into the supercharger.

## Propeller

The Daimler-Benz DB 605 engine drives a three-bladed V.D.M. (Vereinigte Deutsche Metallwerke, the manufacturer) constant speed propeller with metal blades. The blade pitch is adjusted automatically via an electro-mechanical system that also has a manual override.

The automatic pitch control sets the pitch such that the desired engine speed is provided at any boost pressure. Both boost pressure and RPM are set to current altitude pressure.

The automatic switch is located on the left side of the cockpit underneath the throttle quadrant.

A convenient thumb switch is also provided on the throttle quadrant allowing manual prop pitch adjustment. The manual setting can be used in emergencies, or for increased fuel economy.

The position of each propeller blade is shown with the mechanical position indicator FL. 18503/2 on the main instrument panel.

The indicator looks like a clock with hour and minute hands, but its hands rotate counterclockwise. One hour indicates six degrees of pitch, ten minutes equal one degree of pitch.

The minimum pitch, 26 degrees, corresponds to 12:30 on the indicator.

The maximum pitch, 89 degrees, corresponds to 6:00 on the indicator.

The table on page 92 shows clock indications and their corresponding prop pitch positions in percent.

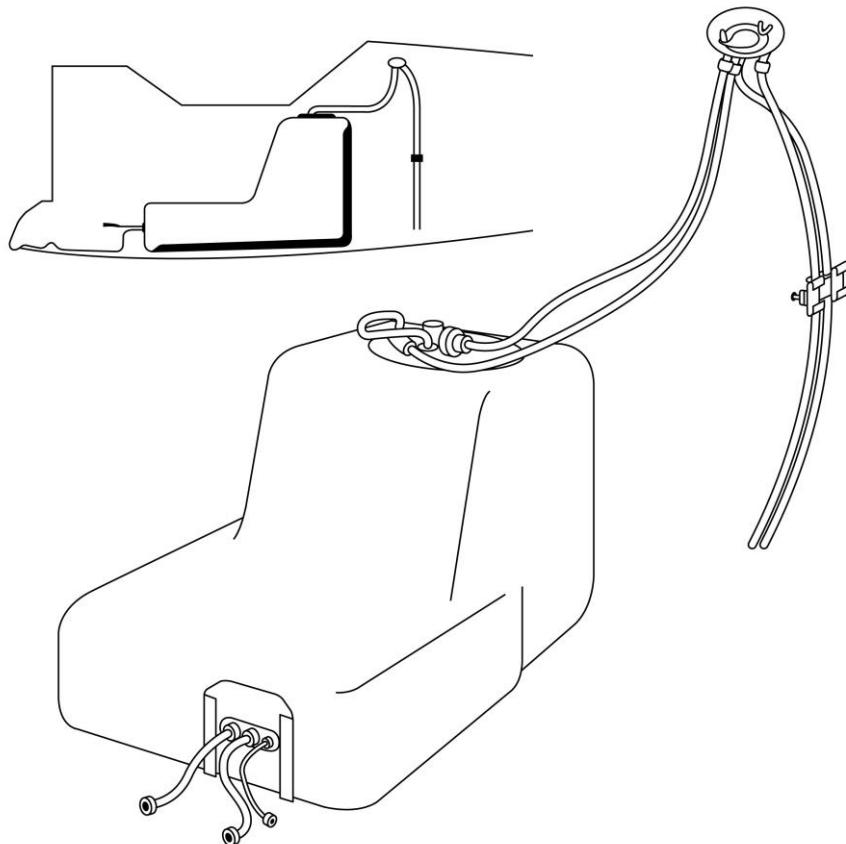


**Figure 33: Propeller Pitch Position Indicator showing 10:30 or 38 degrees prop pitch**

## Fuel System

The Bf 109 K, as most Bf 109 variants, uses a single main 400-liter L-shaped fuel tank located partly under the cockpit floor and partly behind the rear cockpit bulkhead.

The Bf 109 K-4 can also carry an external drop tank under the fuselage with the capacity of 300 liters.



**Figure 34: Main Fuel Tank**

The fuel system operates on a simple principle. When more than one fuel tank is used, all tanks are daisy-chained and fed into one another.

Two fuel pumps are provided, P1 and P2. P1 draws fuel from the rear section of the tank, while P2 draws fuel from the front of the L-shaped tank. A Fuel Feed Selector located below the throttle quadrant is used to switch between the fuel pumps, with the options of "Zu" (closed, i.e. both off), P1 (P1 pump), P2 (P2 pump), and P1+P2 (both).



**Figure 35: Fuel Feed Selector**

A single Fuel Contents gauge is also provided on the front dash indicating remaining fuel in hundreds of liters.



**Figure 36: Fuel Contents Gauge and Fuel Warning light**

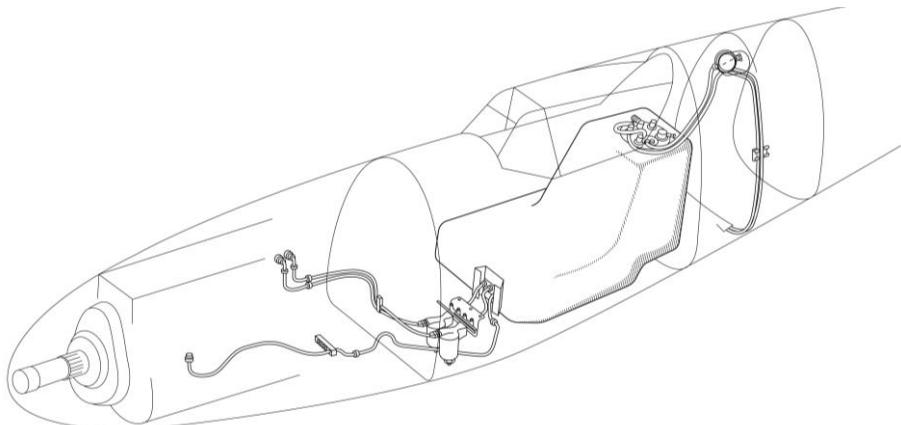
A Fuel Warning Light is also provided for the main tank. The light illuminates when the fuel level in the main tank reaches approximately 30 liters - enough fuel for approximately 5 minutes of flight.

A Fuel Pressure gauge is provided that monitors the fuel pressure as fed from the main fuel tank to the engine.



**Figure 37: Fuel Pressure (left side) Gauge**

The engine always draws fuel from the main tank.



**Figure 38: Fuel System Overview**

When a drop tank is used, it constantly feeds the main tank via a pressurized fuel hose. The Fuel Contents Gauge will continue to display full for as long as the drop tanks continue to feed the main tank. Once the drop tank is emptied, the fuel quantity in the main tank begins to decrease.

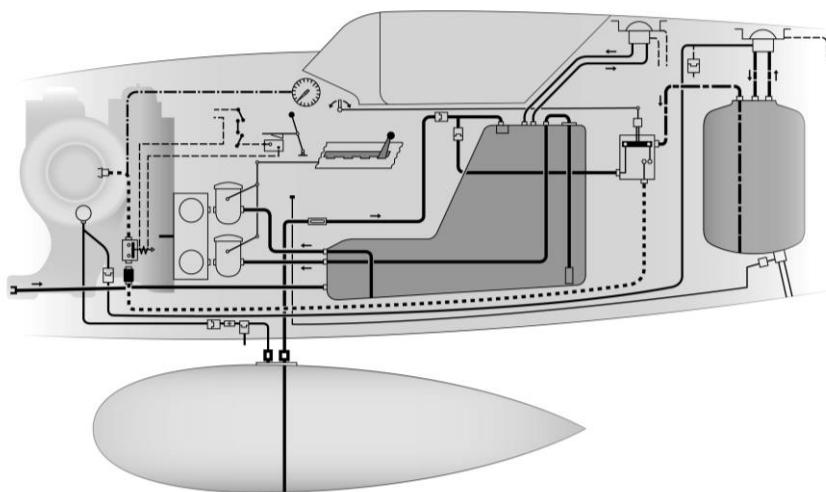


Figure 39: Fuel System Diagram

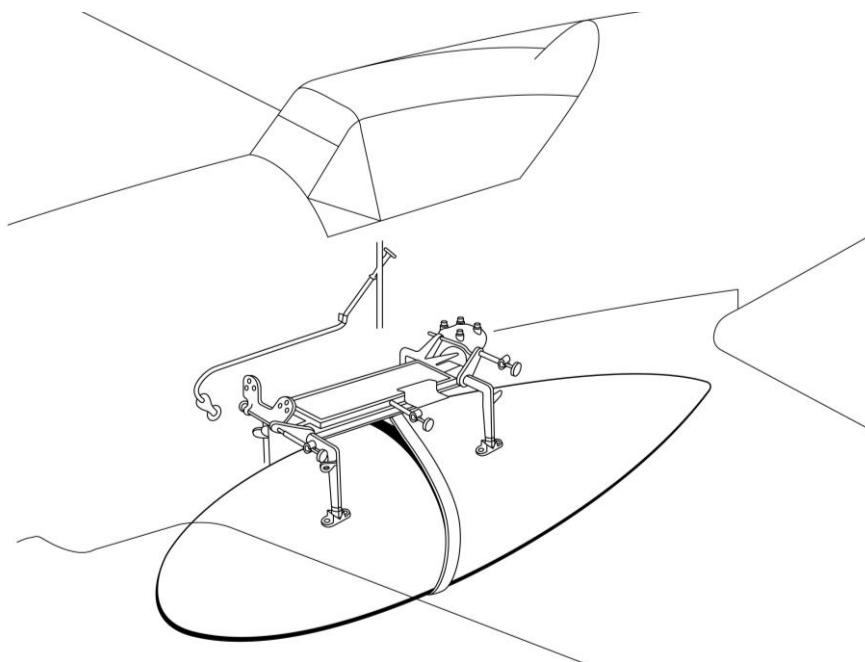


Figure 40: Drop Tank Fuel System

## Hydraulic System

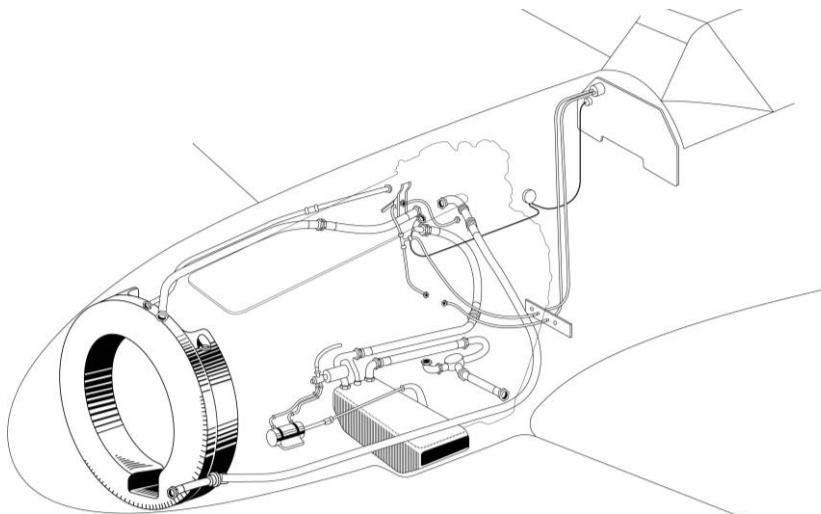
The hydraulic system in the Bf 109 is used to operate the landing gear and radiator's flaps.

The landing gear is normally raised and lowered hydraulically. The engine fluid radiators and oil radiator have hydraulically controlled flaps.

## Oil System

The oil system of the DB 605 has a dry sump with one pressure and two scavenge pumps.

A circular oil tank is located in the nose. As no armor protection is provided for the oil system, the oil tank and the oil cooler are some of the aircraft's most vulnerable spots.



**Figure 41: Oil System Diagram**

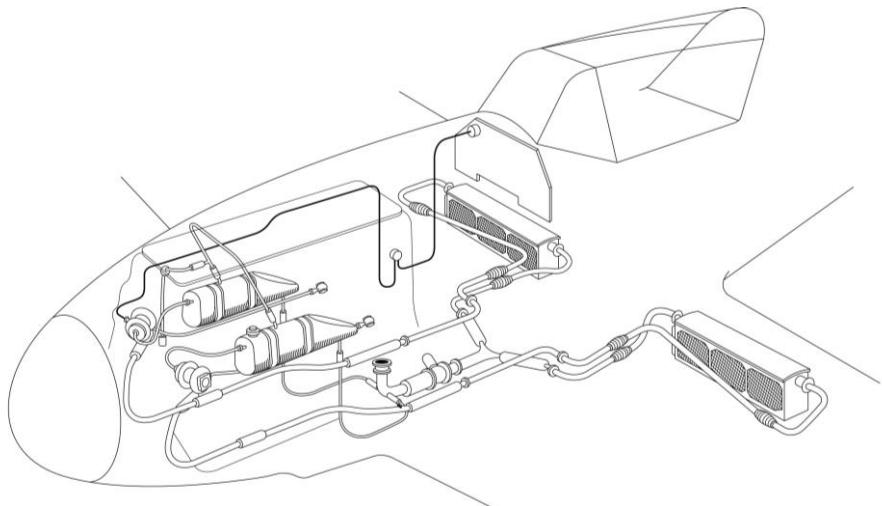
Two cockpit gauges are provided, both on the front dash. The Oil Temperature gauge monitors the system with the normal operating temperature range of 70-85 degrees. The right-hand side of the Fuel and Oil Pressure gauge monitors the system with the normal pressure of 5 – 10 kg/cm<sup>2</sup>.



**Figure 42: Oil Pressure (right) and Oil Temperature Gauges**

## Coolant System

The Bf 109 K-4 uses two matching radiators partially recessed in the wings for cooling. First introduced during a radical redesign of the F (for Friedrich) variant, the system used a system of interconnected flaps to efficiently regulate cooling while providing the least possible drag. The flaps are controlled automatically by a thermostat that works to provide maximum cooling by moving the flaps in unison as needed.



**Figure 43: Coolant System Diagram**

The automatic system can be somewhat sluggish, especially on the ground. Common pilot tactic is to nudge the throttle slightly on take-off to reach the proper temperature limit, causing the automatic cooler flaps to open or close as needed.

Manual override for the system is also provided, but should be used only in the case of emergency; during normal operation it is highly recommended to use the automatic system.

## Electrical System

The electrical system is powered by a 2000-Watt 24-Volt generator. The system also contains one 7.5 Ampere-hour battery.

The electrical system powers the following:

- Propeller pitch automation
- Cockpit gauges
- MW-50 circuit
- Fuel pumps
- Weapons system
- FuG 16ZY and FuG 25a Radio sets
- Exterior lights
- Window heating

The Circuit Breaker Panel on the right-hand side of the cockpit is used to power up the components.

Each circuit breaker has two buttons. The larger black button with a white dot switches the corresponding circuit on. The red button opens the circuit and thus switches it off.

Each circuit is designed to pop out if overloaded and can be reset by pushing the black button in.

The following buttons are provided:

<b>A100</b>	Stromerzeuger	24V 2000W Generator
<b>D100</b>	Staurohr Sichtscheibenheizung Heizhandschuhe	Pitot Heater Window Heating Heated Gloves
<b>C100</b>	Kennlichter	Exterior Lights
<b>C101</b>	UV-Leuchten	Interior Lights
<b>V101</b>	Abwurfwaffe Gondeln Bildgeräte Aufklärer Messgeräte	Drop Ordnance and Optional Armament Gun or Recon Camera Instruments

<b>V100</b>	KGM1 Anlage Anlasszündung Leuchtm-Abschussanlage Verstell-Luftschraube Fahrwerküberwachung Fernkompass Revibeleuchtung	MW-50 System Starter Ignition Flares Prop Pitch Automation Landing Gear Compass Revi Illumination
<b>A101</b>	Sammler	24V, 7.5 Ah Battery
<b>F135</b>	FuG 16	FuG 16 Radio Transmitter & Receiver
<b>F211</b>	FuG 25a	FuG 25a IFF Unit
<b>E101</b>	Tankpumpe	Electrical Fuel Pumps



**Figure 44: Electrical Cockpit Controls**

The Kill Switch illustrated below and located on the main dashboard is used to disable the aircraft's main electrical power.



**Figure 45: Electrical Kill Switch**

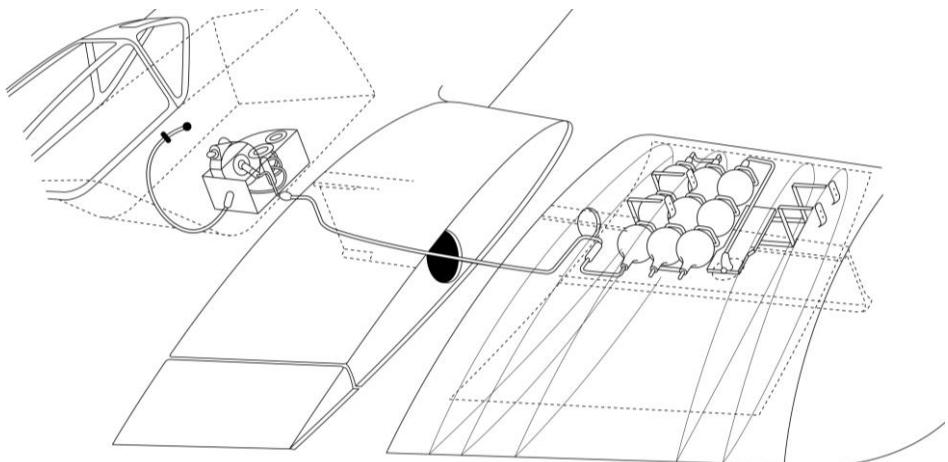
## Oxygen System

The oxygen system consists of a cockpit-mounted flow valve with the attached flow monitor, the regulator unit with oxygen hose, and high-pressure lines with pressure gauge, and a set of spherical 2-liter bottles located in the right aircraft wing that contain the oxygen. The bottles are split into three banks of three as an additional safety measure.



**Figure 46: Oxygen Flow Indicator and Pressure Gauge**

Opening the flow valve starts the flow of oxygen. Oxygen flows to the regulator unit. The provided Flow Indicator and the Pressure Gauge located on the right-hand side of the front dash correspondingly indicate system status.



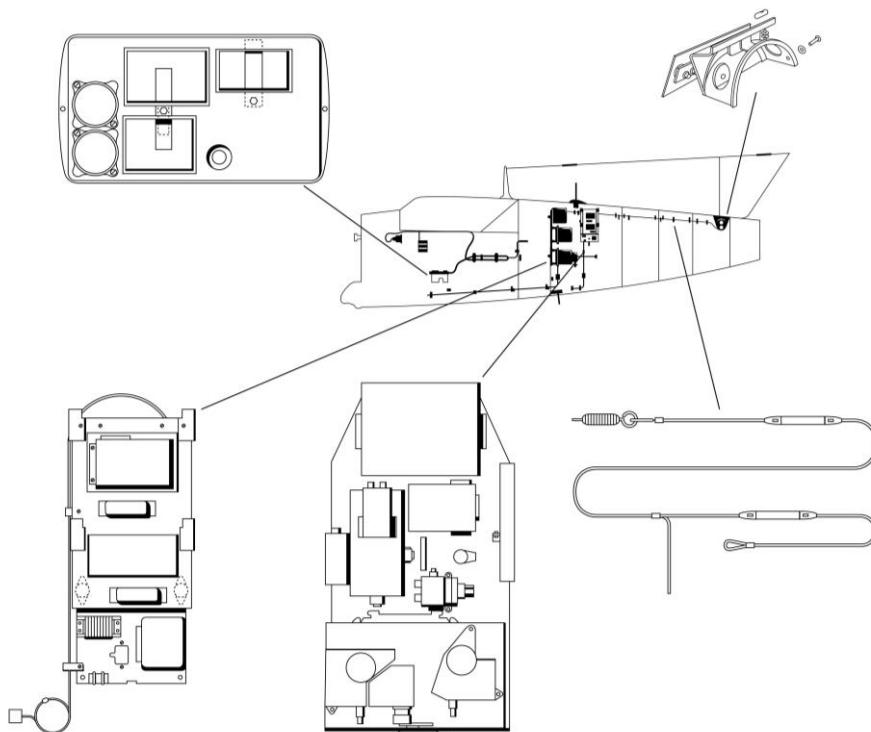
**Figure 47: Oxygen System Diagram**

## Radio Equipment

The aircraft is equipped with a FuG 16ZY radio, a specially-designed airborne VHF transceiver. The FuG 16 can be used for in-flight communication as well as for IFF identification and DF homing. The set operates in the frequency range between 38.4 and 42.4 MHz.

The FuG 16ZY can also be set to Leitjäger or Fighter Formation Leader mode that allows it to use a special Y-Verfahren ground tracking and direction homing via the normal headphones.

The AFN-2 component of the radio set allows easy navigation to ground-based homing beacons, showing both direction and range on one simple dial.



**Figure 48: Radio Equipment Diagram**

The FuG 25a Erstling (Debut) component is one of the world's first Identification Friend or Foe (IFF) units that allows ground-based radar to identify the aircraft as friendly. The unit receives impulses from Freya or Würzburg radar stations. When enabled and properly set with the day's codeword, the FuG 25a replies with a pre-defined signal that the ground station can process to identify the unit as

friendly. The FuG 25a operates in the frequency range of 125 +/- 1.8 MHz, with an operating range of up to 100 km.

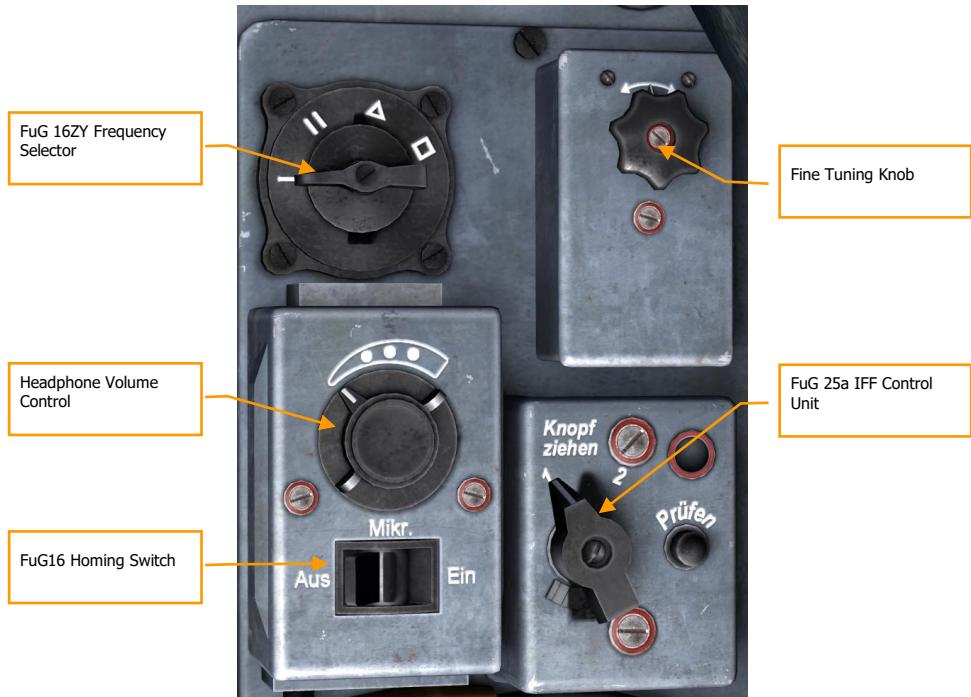


Figure 49: FuG 16ZY Controls

## Armor

The Bf 109 K-4 offers plentiful all-around pilot protection that includes an armored headrest, armored seat back, as well as an armored cockpit windscreens.

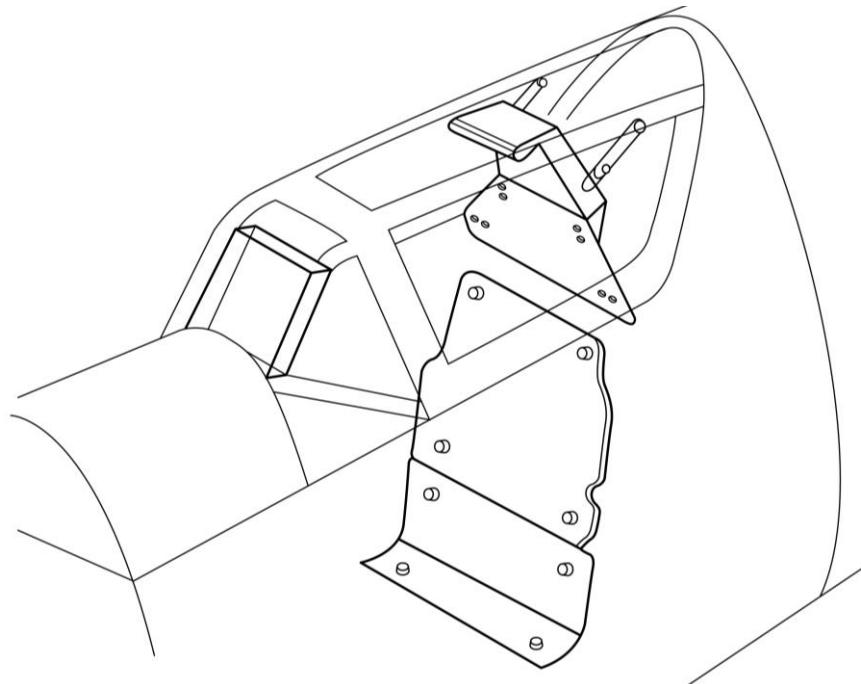
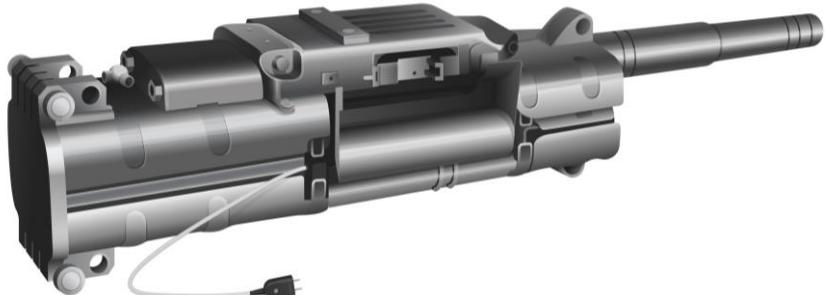


Figure 50: Bf 109 K-4 Cockpit Armor

## Armament

The armament of the K-4 consists of a 30 mm (1.18 in) MK 108 engine-mounted cannon (Motorkanone) with 65 rounds, and two 13 mm (.51 in) MG 131s in the nose with 300 rounds per gun. Some production K-4s were fitted with the MG 151/20 as the Motorkanone. Additional Rüstsätze, or equipment kits, such as a 300 L (80 US gal) drop tank (R III), bombs up to the size of 500 kg/1,100 lb (R I), underwing 20 mm Mauser MG 151/20 cannon gondola pods (R IV) or 21 cm (8 in) Wfr.Gr. 21 rockets, were also provided for.



**Figure 51: MK 108 Cannon**

An important fact that must be mentioned when discussing the armament is the quality of German ammunition. Largely ahead of its time and superior to comparable Allied examples, German cannon shells use centrifugal fusing in shells which contain several times more explosive than Allied shells due to the use of thinner walls. High-quality explosives used in the shells also provide considerably more punch than comparable Allied examples.



**Figure 52: MK 108 engine-mounted cannon and two MG 131s machineguns above engine**

The Bf 109 uses electrically operated guns, as do most other German aircraft of WWII. This makes weapon selection easier than on Allied aircraft, and also enables a unique system of ammunition counters that takes all guesswork out of aerial gunnery.

Cockpit equipment for the armament includes the Revi 16B gunsight as well as the SZKK 3 ammunition counters. While provisions were made for the more advanced lead-computing EZ 42 gunsight, late-war production difficulties meant that production K-4s shipped with the simpler Revi 16B.

The SZKK 3 ammunition counter is from the SZKK (Schalt-, Zähler- und Kontrollkasten) family of German indicators used on many Luftwaffe aircraft during WWII. While most pilots from other air forces had to estimate the amount of ammunition remaining in their weapons, German pilots have the luxury of seeing the actual amount of ammunition in their stores right in their cockpit.



**Figure 53: SZKK 3 Ammunition Counter**

The SZKK 3 shows the ammo stores for each of the two MG 131. The left-hand vertical bank in the SZKK show the state of the left MG 131, and the right-hand indicator the right MG 131.

Please note that no cockpit indication is provided for the MK 108.

The ammo counters are not directly linked to the ammo stores. Instead, they are reset to full (top) position when the guns are loaded on the ground, and then each mechanical indicator bar is lowered whenever a weapon is fired.

White bar portion signifies ammunition in the stores; black bar portion signifies expended ammunition.

The circular Lock Control Indicators on top of each ammunition counter will flicker black and white whenever a weapon is fired. If the lock control indicator remains black when a trigger is pressed, weapon malfunction has occurred.



**Figure 54: Rev 16B Gunsight**

The Rev 16B is a standard reflector sight used on many German aircraft. While attempts to introduce lead-computing sights began rather early in the war, the RLM continued to prefer simpler Reflex Sights (Reflexvisier or Rev 16B for short) well into 1944. All reflex sights used by all nations use the same basic principle and project a reticule image onto a sight glass into infinity.

Reflector sights such as the Rev 16B do not compute lead and simply provide a dead aiming point relative to the aircraft gun line.

When using a reflex sight in combat, the pilot has to make manual adjustments to account for target lead, G load, distance to target, and other parameters required for accurate aerial gunnery.



**Figure 55: Flight Stick**

A conventional flight stick is provided with a conventional trigger that allows the pilot to fire on-board armament as needed.

Two separate triggers are provided, one for the twin MG 131s, and the other one for the MK 108 cannon.

If equipped with the underwing rockets, the MK 108 Fire Button can also be used to fire the underwing rockets. The two modes are selected via the MK 108 / Rockets Switch located on the main dash.

The stick also contains the Bomb Release Button that can be used to drop the bomb.

If equipped with underwing cannon gondolas, the MK 108 can also be used to fire the underwing guns. The two modes are selected via the Wing Cannon Switch located on the main dash.

# COCKPIT



## COCKPIT

The pilot's office in the Bf 109 K-4 is a conventional aircraft cockpit that is rather cramped and disorganized by late-war standards. A long series of improvements and adjustments in the Bf 109 variants meant that the original clean Bf 109 B cockpit continued to receive a large number of switches and controls for new devices that were often placed haphazardly in areas convenient to the engineers with little regard for ergonomics.

In stark contrast to its competitor, the Fw 190, the Bf 109 requires the pilot to often take hands off throttle or stick, sometimes requiring minor feats of strength or contortion to operate various cockpit systems.

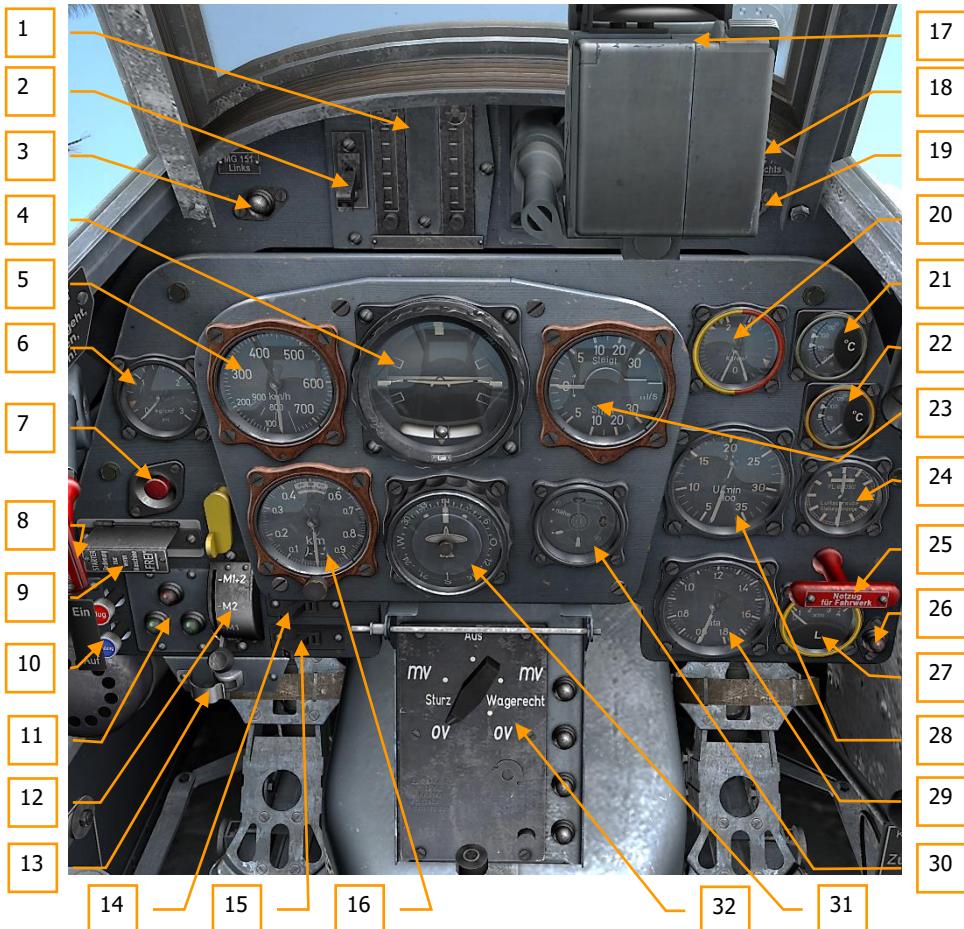


**Figure 56: Bf 109 K-4 Cockpit Overview**

The cockpit is divided into three main areas: the front dash includes the instrument panel and the Revi 16B gunsight; the left-hand side that includes engine controls; and the right-hand side that includes oxygen controls and the electrical system breakers.

## Front Dash Legend

The front dash includes the instrument panel and the Revi 16B gunsight.



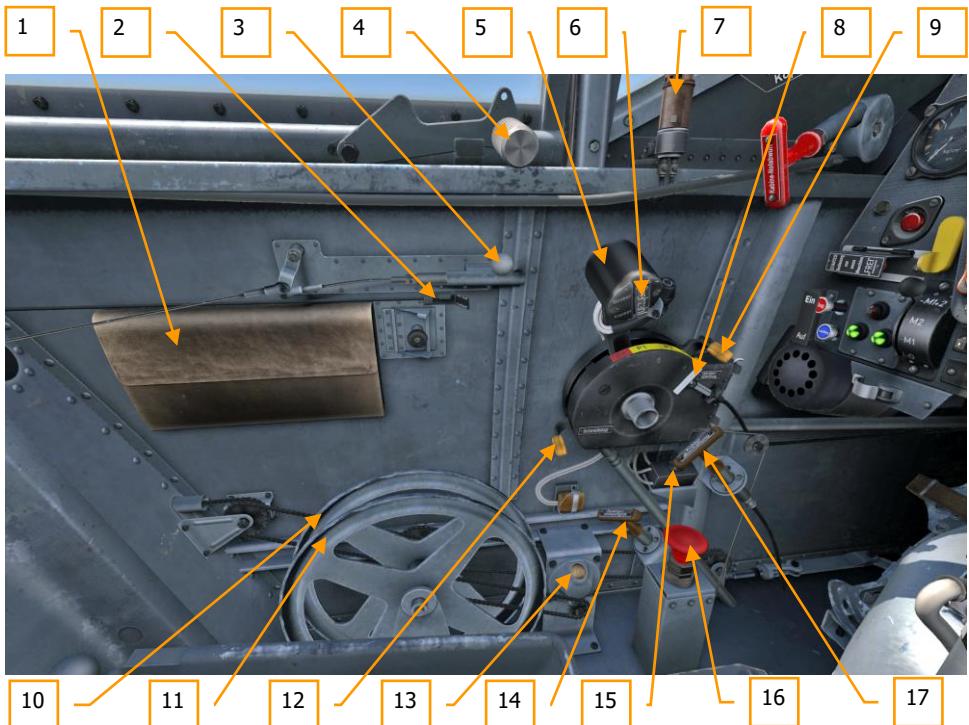
**Figure 57: Bf 109 K-4 Front Dash and Legend**

1. Ammo Indicators
2. Master Weapons Switch
3. Wing mounted MG 151 Indicator (Left)
4. Artificial Horizon / Turn & Bank Indicator

5. Airspeed Indicator
6. Water/Methanol Pressure Gauge
7. Electrical Kill Switch
8. Canopy Jettison Handle
9. Starter Switch
10. Landing Gear Controls
11. Landing Gear Position Indicator
12. Ignition (Magneton) Selector
13. MK 108 / Rockets Switch
14. MW-50 Power Switch
15. Wing Cannons Switch
16. Altitude Indicator
17. Revi 16B Gunsight
18. Flight Clock (obscured)
19. Wing mounted MG 151 Indicator (Right)
20. Fuel & Oil Pressure Gauge
21. Coolant Temperature Gauge
22. Oil Temperature Gauge
23. Vertical Speed Indicator
24. Prop Pitch Indicator
25. Landing Gear Manual Release
26. Fuel Warning Light
27. Fuel Contents Gauge
28. Tachometer
29. Supercharger Pressure Gauge
30. AFN-2 Homing Indicator
31. Repeater Compass
32. Bomb Control Panel

## Left Side Legend

The left-hand side includes engine controls and flap and trim controls.



**Figure 58: Bf 109 K-4 Left Side and Legend**

1. Map Case
2. MW/Fuel Selector Handle
3. Tail Wheel Lock Handle
4. Canopy Handle
5. Throttle Lever
6. Propeller Pitch Rocker Switch
7. Left UV Lamp of Dashboard Illumination
8. Cold Weather Start Handle

9. Fuel Pump Selector
10. Flap Control Handwheel
11. Horizontal Stabilizer Trim Handwheel
12. Engine Stop Handle
13. Horizontal Stabilizer Trim Indicator
14. Ordnance Emergency Release Handle
15. Governor Automation Switch
16. Fuel Priming Pump Handle
17. Left Radiator Cut-Off Handle

## Right Side Legend

The right-hand side includes oxygen controls, weapon controls, and electrical system breakers.

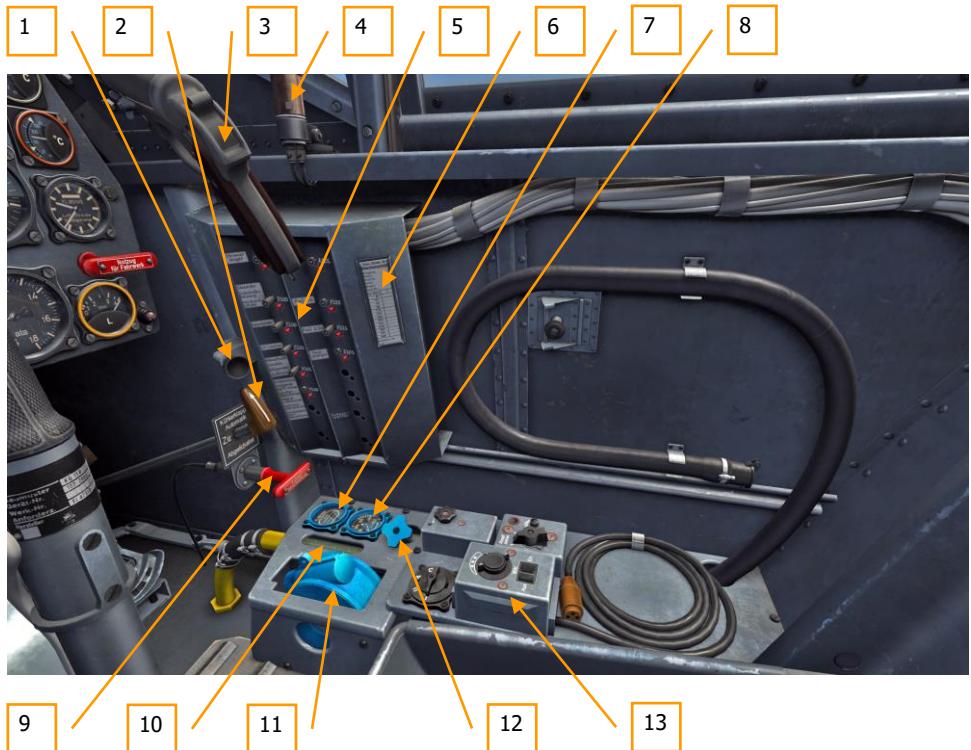


Figure 59: Bf 109 K-4 Right Side and Legend

1. MW/Fuel Jettison Handle
2. Radiators Mode Selector
3. Flare Pistol
4. Right UV Lamp of Dashboard Illumination
5. Circuit Breaker Panel
6. Compass Deviation Card
7. Oxygen Flow Indicator

8. Oxygen Pressure Gauge
9. Right Radiator Cut-Off Handle
10. External Tank Fuel Flow Monitor
11. Oxygen Regulator
12. Oxygen Operating Valve
13. FuG 16ZY Radio Controls

## Stick

The KG-13C (Knüppelgriff) stick is placed in the center of the cockpit. The lateral movements hand over the roll control and the longitudinal movements the pitch control.

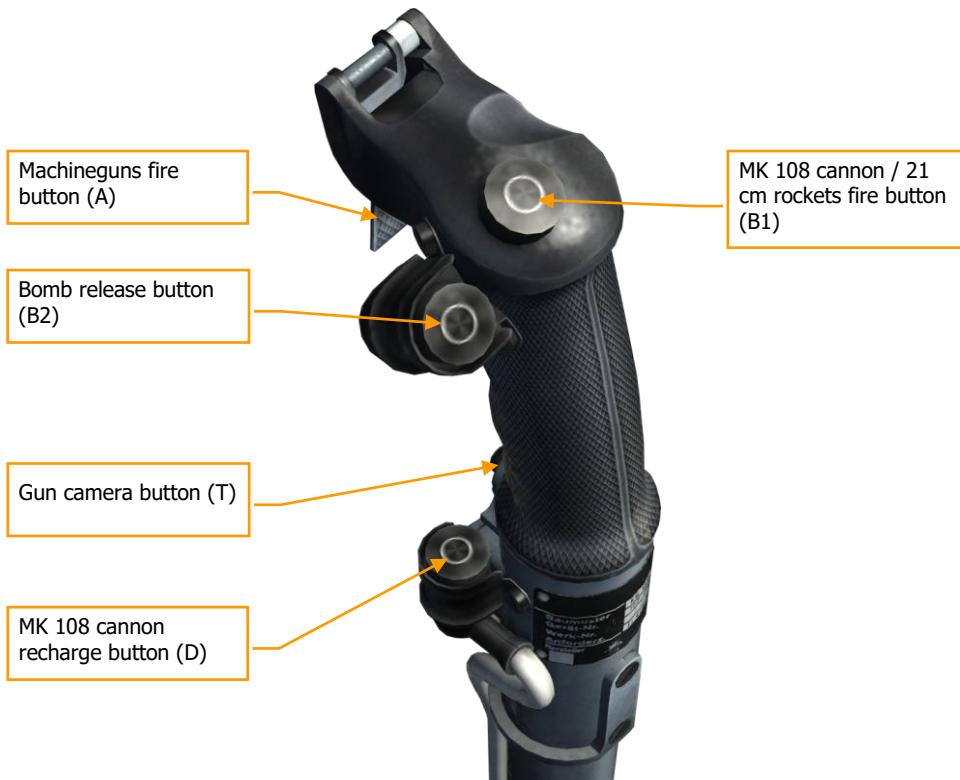


Figure 60: Stick

## Front Dash Indicators and Controls

This section will overview in detail all of the indicators and controls located on the front dash.

### Revi 16B Gunsight



**Figure 61: Revi 16B Gunsight in unfolded combat position**

The standard Revi 16B reflector sight is fitted to the Bf 109 K-4. It was slated to be replaced later by the EZ 42 Gyro gunsight, but this never materialized due to late-war supply troubles.

The Revi 16B is a standard reflector sight used on many German aircraft. While attempts to introduce lead-computing sights began rather early in the war, the RLM continued to prefer simpler Reflex Sights (Reflexvisier or Revi for short) well into 1944. All reflex sights used by all nations use the same basic principle and project a reticule image onto a sight glass into infinity.

Reflector sights such as the Revi 16B do not compute lead and simply provide a dead aiming point relative to the aircraft gun line.

When using a reflex sight in combat, the pilot has to make manual adjustments to account for target lead, G load, distance to target, and other parameters required for accurate aerial gunnery.

The Revi 16B is equipped with two pilot controls, the Brightness Adjustment Lever and the Sight Dimmer.

The Brightness Adjustment Lever is located on top of the device at the right edge. It can be moved forward (away from the pilot) and backward (toward the pilot) to adjust reticle brightness. In the front position, labelled "Aus" (Off), the light is off. Select the rearmost position for the brightest light. The lever may need to be adjusted based on current light conditions.



**Figure 62: Gunsight's Brightness Adjustment Lever**

The Sight Dimmer is an additional darker sight glass that can be extended behind the main reticle glass. The Dimmer is used in brightest natural light conditions when the rearmost position of the Brightness Adjustment lever is insufficient to adequately display the reticle.

For pilot's convenience, the sight can be pushed to the side when outside of combat to improve visibility. The sight can be folded and unfolded with pivoted sideways by pressing on the sight body.



**Figure 63: Rev 16B Gunsight in folded position**

Press on the gunsight to fold, or unfold it to return it to the combat position.



**Figure 64: Rev 16B Reticule**

The reticule of the Rev 16B has the following markings:

- crosshair with tick marks (the distance between two tick marks equals one degree)
- circle with 50 mil radius (100 mil diameter).

Note:

A radian is a unit of angular measurement.

Mils, short for milliradians, are the thousandth part of a radian.

A mil is a very small angle, about  $1/17^\circ$  ( $0,058824^\circ$ ), and equals approximately one foot at 1000 feet range (or 1 meter at 1000 meters).

Since the angular relationship is linear, 100 mils (=  $1/10$  radian), the diameter of the circle, are  $5.73^\circ$  and equal approximately 100 foot at 1000 feet range (or 100 meter at 1000 meters).

The diameter of the circle closely fits a fighter's wingspan at a distance of 100 m.

The gunsight can be used to determine the distance to a target, as long as its wingspan is known:

A target will fit into the 100-mil circle at a distance of  $10^* \text{wingspan meters}$ .

At half the range, the target will appear twice as large and its mil value will be doubled (200 mils).

At double the range, the target will appear half as large and its mil value will be halved (50 mils).

Example:

A target with a wingspan of 10 m will fit into the 100-mil circle at a distance of 100 m.

At 200 m range, the target's wingspan would equal about 50 mils.

## Instrument Panel

### Ammo Indicators

The SZKK 3 shows the ammo stores for each of the two MG 131. The left-hand vertical bank in the SZKK shows the state of the left MG 131, and the right-hand indicator the right MG 131.

Please note that no cockpit indication is provided for the MK 108.

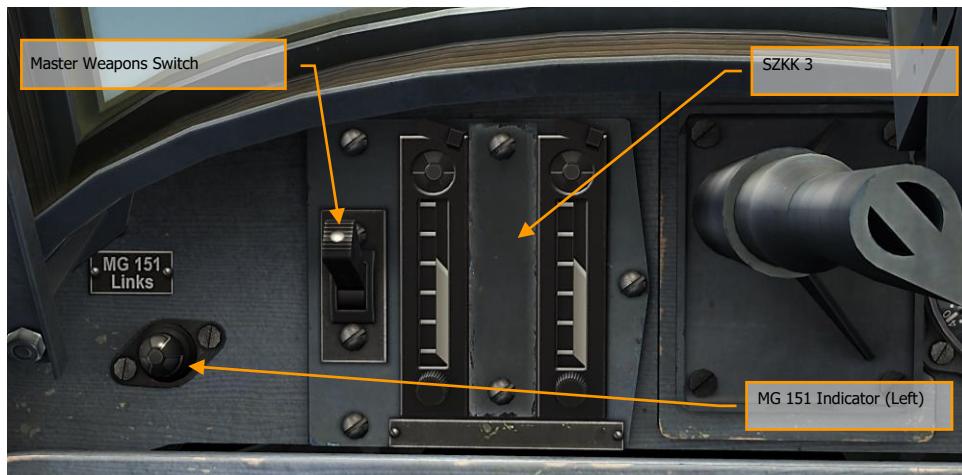
The ammo counters are not directly linked to the ammo stores. Instead, they are reset to full (top) position when the guns are loaded on the ground, and then each mechanical indicator bar is lowered by one notch whenever a weapon is fired.

Notches provided to the side of each indicator show the amount of rounds in the ammo store for each weapon.

White bar portion signifies ammunition in the stores; black bar portion signifies expended ammunition.

The circular Lock Control Indicators on top of each ammunition counter will flicker black and white whenever a weapon is fired. The indicator is directly linked to each weapon's breechblock. If the lock control indicator is black, the breechblock is closed.

If the lock control indicator remains black when the trigger is pressed, a weapon malfunction has occurred.



**Figure 65: SZKK 3 Ammo Indicators, Master Weapons Switch and MG 151 Indicator**

### Master Weapons Switch

The Master Weapons Switch is used to turn on electric power to the nose guns and to commence the weapon loading, when turned on for the first time during a sortie.

Turn the switch up for On; down for Off.

Please note that the Master Weapons Switch only turns on the fuselage cannon. If equipped with underwing gondolas, the switch is located in the main dashboard.

Please keep all weapons turned off for taxi, take-off, and cruise, in order to avoid firing accidents. Only enable weapons when entering combat or when instructed by the flight leader to test fire weapons.

Unlike the weapons in the FW 190, the armament in the Bf 109 K-4 is armed pneumatically with no electric loading. The MG 131s are pneumatically loaded on the ground. The MK 108 is pneumatically reloaded via the reload button. The pushbutton operation is possible as the pneumatic valves are controlled via electrical solenoids.

### MG 151 Indicator (Left)

The indicator light is connected to the left underwing gondola MG 151, if so equipped.

The indicator light illuminates when the Wing Cannon Switch is ON and the V101 switch on the Electrical Circuit Breaker Panel is ON.

## Artificial Horizon / Turn & Bank Indicator

Another commonly used Luftwaffe indicator, this gauge manufactured by Askania in Berlin combines a turn/bank indicator and an artificial horizon into one.

The turn-and-bank portion of the gauge is composed of a gyroscope-type turn indicator and a ball-type bank (slip) indicator. The bank indicator is a liquid-filled curved tube in which a free-rolling inclinometer ball changes position according to the direction of the force of gravity and centrifugal force. The bank indicator is used to minimize side-slip by keeping the ball centered between the center reference lines while turning. The limits of the bank indicator are +/-35°.

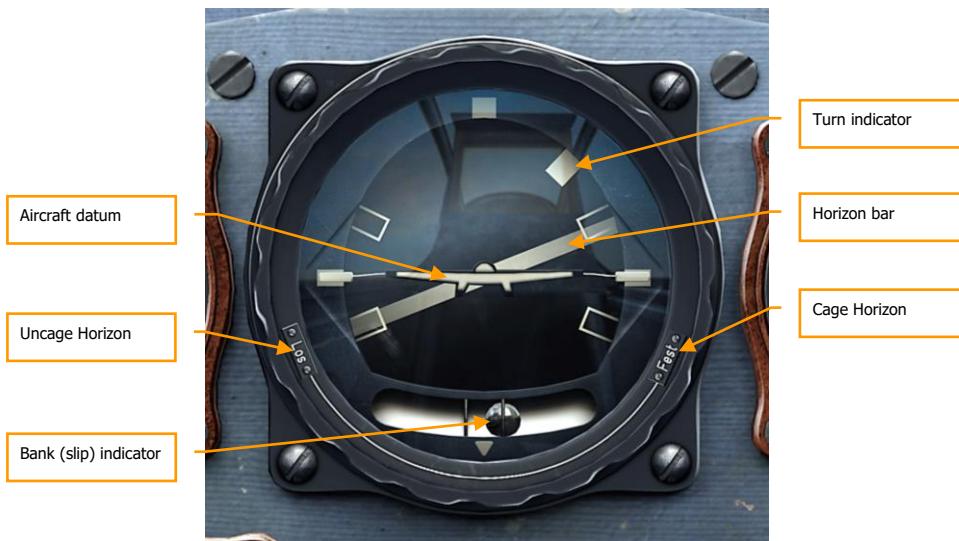
The horizon bar will indicate pitch up to 60° and bank up to 110°.

Please note that if the pitch indicator exceeds 60°, the gyroscope limiter is encountered and correct data can no longer be displayed. The horizon bar is therefore only accurate for pitch of up to 60°.

The top needle of the instrument indicates the angle of bank. The turn indicator showing aircraft rate of turn. At full deflection the indicator is equal to a 360-degree turn in two minutes.

Please note that the artificial horizon bar is locked during aerobatics!

The outer rotary ring is intended for caging/uncaging the artificial horizon. "Fest" is caged and "Los" is uncaged position.



**Figure 66: Artificial Horizon**

## Airspeed Indicator

A later model of a common Luftwaffe airspeed indicator, the gauge in the Bf 109 K-4 bears a km/h designation on the dial.

The FI 22234 Airspeed Indicator is modeled in DCS Bf 109 K-4; some K-4s were also equipped with the FI 22245 Airspeed Indicator graduated from 100 to 1,000 km/h that attempted to show both Indicated and True Airspeed based on air pressure input.

The FI 22234 as modeled displays Indicated Airspeed (IAS) only and is graduated from 0 to 750 km/h on the main outside range, with the airspeed continuing past the 0 mark for up to 900 km/h. The scale is to 10 km/h from 100 to 750 km/h and to 50 km/h thereafter.

Please note that ranges between 0 to 180 and 750 to 900 km/h overlap. No indication other than common sense is used to determine the airspeed within this overlap.



**Figure 67: Airspeed Indicator**

## Water/Methanol Pressure Gauge

The MW-50 Water/Methanol Pressure Gauge (part number Fl. 20504-3) indicates the MW-50 system pressure in kg/cm<sup>2</sup>.

The instrument is graduated from 0 to 3 kg/cm<sup>2</sup>. The gauge is scaled to 0.2 kg/cm<sup>2</sup> throughout. Two indicator strips indicate normal operating pressure of 0.4 – 0.8 kg/cm<sup>2</sup>. The lower indicator strip shows minimum permissible pressure of 0.4 kg/cm<sup>2</sup> and the upper indicator strip the maximum permissible pressure of 0.8 kg/cm<sup>2</sup>.

The "gvy" label on the instrument is the manufacturer code and stands for "J.C. Eckardt A.G, Werk Sonneberg".



**Figure 68: Water/Methanol Pressure Gauge**

## Canopy Jettison Handle

The handle can be used in an emergency to detach the canopy from the aircraft.

Please duck your head when using the Jettison Handle.

If the Jettison Canopy system malfunctions, you may try to open the canopy via the conventional means.



**Figure 69: Canopy Jettison Handle**

## Electrical Kill Switch

The Electrical Kill Switch is used to disable main electrical power in the aircraft.

It is used in emergencies to disable all aircraft functions, or to disable all electrical power at mission end.

It is not recommended to operate this switch in flight, as re-enabling all devices again may be impossible.



**Figure 70: Electrical Kill Switch**

## Starter Switch

The Starter switch is used to start the engine. The switch is spring-loaded and needs to be held in the ON (up) position to execute a start.

Do not operate the starter for over 15 seconds continuously.



**Figure 71: Starter Switch**

## Landing Gear Controls and Landing Gear Position Indicator

This set of pushbuttons allows the operation of the landing gear.

The two available positions are are "**Ein – Flug**" (In/Gear Up - Flight) and "**Aus – Landung**" (Out/Gear Down - Landing).

To raise the landing gear, retract the safety switch over the "**Ein**" (Up) button and press the button. The button remains pressed while the gear is in operation and while the gear is raised and locked. The button does not pop up. The red light also illuminates on the Landing Gear Position Indicator.

To lower the landing gear, press the "**Aus**" (Gear Down) button. The button remains pressed while the gear is in operation and once the gear is down and locked. The button does not pop up. The green Aus lights also illuminate on the Landing Gear Position Indicator.

If a malfunction occurs during the procedure, you may attempt to press the corresponding button again.

Please note that an audible warning sound will be heard in the cockpit whenever the flaps are down while the landing gear is not in the down and locked position. This is to remind you to lower landing gear on landing, or to notify you that the gear malfunction has occurred.



**Figure 72: Landing Gear Controls and Landing Gear Position Indicator**

The Landing Gear Position Indicator shows the position of each main gear leg (left and right) – gear up and gear down.

- When the main gear is up, the red light is on.
- When the main gear is down, corresponding green lights are on.

### Landing Gear Manual Release

When the main gear release button fails to work, a back-up manual system is provided. The emergency lever can be pulled, which unlocks the shock struts mechanically. This in turn allows the landing gear to extend under its own weight.

The aircraft should be in a generally wings-level attitude for the landing gear to drop.

Please note that the back-up system's spring will usually be sufficient to fully lock the landing gear in the down position. If it fails to do so, you may try rocking the aircraft wings.



**Figure 73: Landing Gear Manual Release**

### Ignition Selector Switch

The Ignition Selector switch controls the magnetos used to supply power to the engine ignition system and has four possible positions:

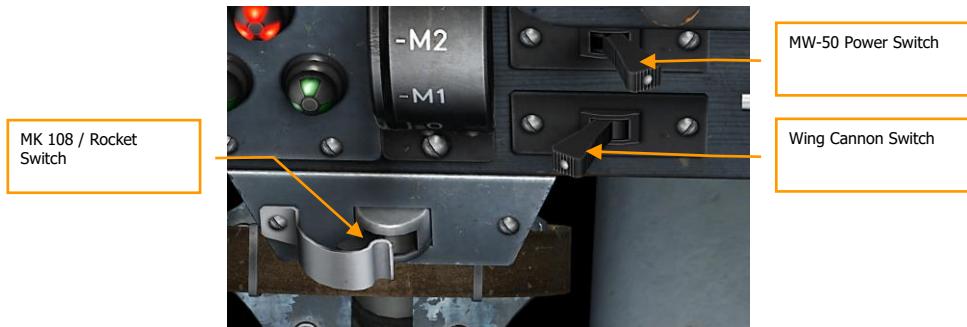
- "**0**". The magnetos are turned off.
- "**M1**". The position is used to check for correct operation of the right magneto.
- "**M2**". The position is used to check for correct operation of the left magneto.
- "**M1+2**". Both magnetos are used.

Only the "**M1+2**" position should be used to start the engine and at all other times during normal operation.



Figure 74: Ignition Selector Switch

## MK 108 / Rocket Switch, MW-50 Power Switch and Wing Cannon Switch



**Figure 75: MK 108 / Rocket Switch, MW-50 Power Switch and Wing Cannons Switch**

**MK 108 / Rocket Switch** toggles firing modes for the B1 button (MK 108 cannon / rockets fire button) located on the KG-13C control stick.

When set to the left-most position, pressing the B1 button will fire the MK 108 cannon.

When set to the right-most position, pressing the B1 button will fire the underwing rockets.

**MW-50 Power Switch** operates the MW-50 water/methanol injection that greatly increases engine power.

Set it to right position to enable the MW-50 system; set it to left to disable it.

No On/Off indicator is provided; however system status can be ascertained by watching the Supercharger Pressure Gauge, the Water/Methanol Pressure Gauge, and simply by listening to the engine sound.

While the system is not normally used on the ground or at lower airspeeds, it can be used on shorter runways with higher boost settings when needed.

**Wing Cannon Switch** toggles firing modes for the underwing cannon, if so equipped.

Please note that only one underwing weapon can be equipped at one time. If equipped with an underwing cannon, no rockets can be carried, and vice versa.

At the same time, the MK 108 / Rocket Switch is still operational even when no rockets are carried. When no rockets are equipped, the switch simply toggles the operation of the MK 108.

When the wing cannon Switch is set to the left-most position, the MK 108 Fire button on the main control stick will only fire the weapon selected by the MK 108 / Rocket Switch (MK 108 or nothing).

When the wing cannon Switch is set to the right-most position, the MK 108 Fire button will fire the underwing guns together with the weapon determined by the MK 108 / Rocket Switch (MK 108 or nothing).

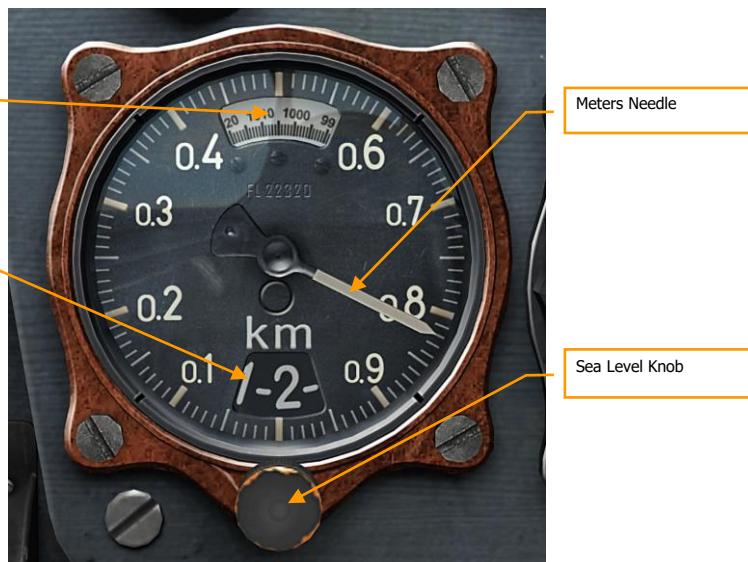
## Altitude Indicator

The Altitude Indicator (part number FI. 22320, manufactured by R. Fuess) determines the altitude at which the aircraft is flying by measuring atmospheric pressure. The instrument consists of 3 parts; the needle indicates altitude in tens of meters, the lower window shows the kilometer disk, and the upper window shows barometric pressure in Millibar.

The gauge is graduated from fractions of 1 km from 0.0 to 0.99. The scale is 1/100 of a km, or 10 meters, throughout.

The kilometer disk shows even kilometers of altitude, rounded down. The disk can show numbers from 0 to 9, for a total limit from 0 to 9,999 meters.

The information shown by the meters needle and the kilometer disk should be added. For example, if the km disk shows 3 and the needle points at 0.75, the actual altitude is 3,750 meters ( $3 + 0.75 \text{ km}$ ).



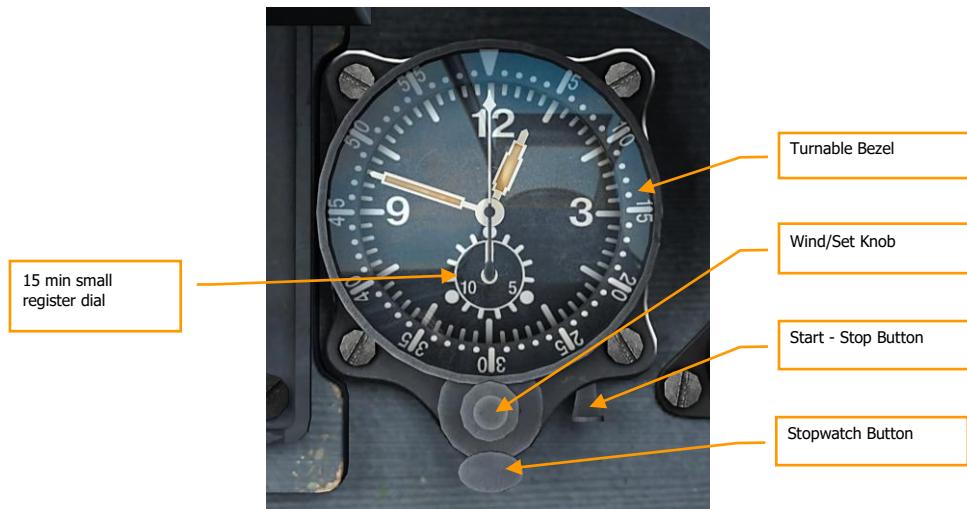
**Figure 76: Altitude Indicator**

## Flight Clock

The "Junghans Borduhr Bo-UK1" was the standard instrument chronograph for all German aircraft in WWII. The clock is installed at the top right corner of the Bf 109's main dash.

You can adjust the clock with the round Wind/Set Knob below. The button under it starts the stopwatch, arrest it and put it back. With the Start - Stop Button on the right and the round button you are able to set the clock.

The stopwatch mechanism is started and stopped by pressing the stopwatch button, located directly below the wind/set knob. First press to start, second press to arrest and third press to put it back. Each passing of the sweep second is recorded, up to 15 minutes, on the small register dial.



**Figure 77: Flight Clock**

Adjust clock:

- Pull down the Start-Stop button.
- Adjust desired time on Wind/Set Knob with mouse wheel.
- Push back the Start-Stop button.

Stopwatch:

- Start stopwatch with first press of stopwatch button.
- Arrest stopwatch with second press of stopwatch button.
- Put it back with third press of stopwatch button.

## Fuel and Oil Pressure Gauge, Coolant and Oil Temperature Gauges

**Fuel and Oil Pressure Gauge** is typical pneumatic double pressure gauge for fuel and oil, with two independently operating measuring stations and terminals. Manufacturer is the Maximall-Apparatus company, Paul Willmann / Berlin.

The gauge is divided into two sections. The left-hand side gauge and needle show fuel pressure in kg/cm<sup>2</sup>. The right-hand side gauge and needle show oil pressure in kg/cm<sup>2</sup>.

The fuel pressure gauge is graduated from 0 to 2 kg/cm<sup>2</sup>. The gauge is scaled to 0.1 kg/cm<sup>2</sup> throughout. Two indicator strips indicate normal operating pressure of 1.6 - 1.8 kg/cm<sup>2</sup>. The lower indicator strip shows minimum permissible pressure of 1.6 kg/cm<sup>2</sup> and the upper indicator strip the maximum permissible pressure of 1.8 kg/cm<sup>2</sup>.

The oil pressure gauge is graduated from 0 to 10 kg/cm<sup>2</sup>. The gauge is scaled to 1 kg/cm<sup>2</sup> throughout. Two indicator strips indicate normal operating pressure of 3.5 - 9.5 kg/cm<sup>2</sup>. The lower indicator strip shows minimum permissible pressure of 3.5 kg/cm<sup>2</sup> and the upper indicator strip the maximum permissible pressure of 9.5 kg/cm<sup>2</sup>.



Figure 78: Fuel and Oil Pressure Gauge, Coolant and Oil Temperature Gauges

**Coolant Temperature Gauge** shows the temperature of the coolant fluid. The gauge indicates temperature in degrees Celsius (°C) and is graduated from 0° to 130°C. The face is scaled to 10°C. Two indicator strips indicate normal operating temperature of 60° - 110°C. The lower indicator strip shows minimum permissible temperature of 60°C and the upper indicator strip shows the maximum temperature of 110°C while flying at medium altitude. The maximum continuous safe temperature for all the aircraft's altitude range is 105°C.

**Oil Temperature Gauge** shows the temperature of the oil. The gauge indicates temperature in degrees Celsius ( $^{\circ}\text{C}$ ) and is graduated from  $0^{\circ}$  to  $130^{\circ}\text{C}$ . The face is scaled to  $10^{\circ}\text{C}$ . Two indicator strips indicate normal operating temperature of  $30^{\circ} - 130^{\circ}\text{C}$ . The lower indicator strip shows minimum permissible temperature of  $30^{\circ}\text{C}$  and the upper indicator strip the maximum permissible temperature of  $130^{\circ}\text{C}$ .

### Vertical Speed Indicator

The Vertical Speed Indicator or Variometer shows the rate of ascent or descent of the aircraft. The instrument is graduated from 0 to 30 m/s in both positive and negative directions and indicates vertical speed in meters per second. The face is scaled to 1 m/s between 0 and 5 m/s, and to 5 m/s thereafter.

The Variometer is used to maintain a constant altitude when turning and to establish a definite and constant rate of climb or descent when flying on instruments.

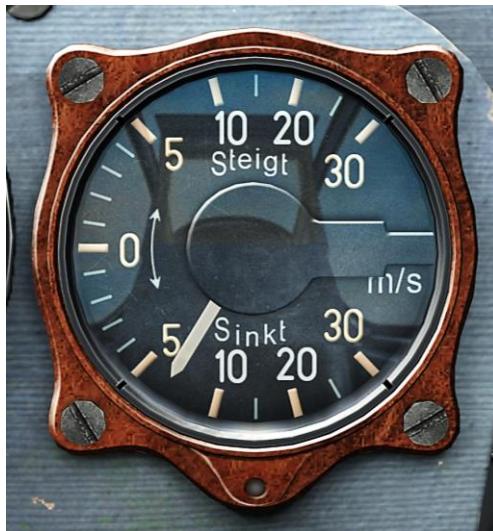


Figure 79: Vertical Speed Indicator

### Prop Pitch Indicator

The gauge indicates the position of each propeller blade. The needles should be read like clock hands, with the 6:00 position for 100% pitch, and 12:30 for 0%.

The indication and their corresponding prop pitch position should be read according to the following table:

Indicator	Pitch	Indicator	Pitch	Indicator	Pitch
6:00	<b>100%</b>	6:19	<b>95%</b>	6:39	<b>90%</b>
6:58	<b>85%</b>	7:18	<b>80%</b>	7:37	<b>75%</b>
7:57	<b>70%</b>	8:16	<b>65%</b>	8:36	<b>60%</b>
8:55	<b>55%</b>	9:15	<b>50%</b>	9:34	<b>45%</b>
9:54	<b>40%</b>	10:13	<b>35%</b>	10:33	<b>30%</b>
10:52	<b>25%</b>	11:12	<b>20%</b>	11:31	<b>15%</b>
11:51	<b>10%</b>	12:10	<b>5%</b>	12:30	<b>0%</b>



Figure 80: Prop Pitch Indicator in 9:34 Position

## Fuel Contents Gauge and Fuel Warning Light

A single fuel gauge is provided for both the main tank and the optional drop tank.

Please note that there is no fuel content information for drop tanks.

The engine always draws fuel from the main tank. If a drop tank is used, its fuel pump feeds the main tank.

When drop tanks are used, the Fuel Contents Gauge will continue to display full for as long as the drop tanks continue to feed the main tank. Once the drop tanks are emptied, the fuel quantity in the main tank begins to decrease.



**Figure 81: Fuel Contents Gauge and Fuel Warning Light**

The Fuel Warning Light illuminates when the fuel level in the main tank reaches approximately 30 liters, equal to about 5 minutes of flight time.

## Tachometer

The Tachometer (part number Fl. 20227, manufactured by Elektro-Lux AG in Berlin) provides remote indication of engine speed.

The actual speed of the motor is gauged with an electric sensor and then transmitted to the speed indicator. The absolute maximum permissible speed of the DB 605 DB is 2850 RPM.

The instrument is graduated from 400 to 3600 and indicates engine speed as Revolutions Per Minute (RPM) in hundreds of RPM. The face is scaled to 100 RPM throughout. The normal operating rate is 2000 – 2400 RPM.

**Please note that, like in many Allied aircraft, the Manifold Pressure gauge is used to set power in the Bf 109 K-4. The Tachometer merely provides feedback from the engine.**



**Figure 82: Tachometer**

### Supercharger pressure gauge

A standard instrument built by R. Fuess in Berlin, this gauge was found in almost all piston engine Luftwaffe aircraft. This device was used to monitor the charge pressure of the engine supercharger.

The gauge is graduated from 0.6 to 1.8 atmospheres absolute. The scale is to 0.02 ata throughout.



**Figure 83: Supercharger Pressure Gauge**

## AFN-2 Homing Indicator

This ubiquitous device was installed in most German aircraft of WWII. In the Bf 109 K-4, the AFN-2 indicator is a part of the FuG 16ZY equipment set.

The AFN-2 indicator allows for easy navigation to ground-based homing beacons, showing both direction and range on one simple dial.

The vertical bar indicates the deviation from direction of the beacon. If the bar goes left, you should turn right to line up on the beam; if the bar goes right, you should turn left.

The horizontal bar indicates the power of the signal that depends on range in a logarithm function. The stronger the signal strength indicated, the closer you are to the homing beacon.

Since no immediate indication is available that shows whether a beacon is ahead or behind the aircraft, a simple test must be made. Gently press the left rudder pedal to swing the nose. If the AFN-2 vertical bar also swings left, you are flying towards the beacon. If the AFN-2 vertical bar swings right, you are flying away from the beacon.

**The frequency of the AFN-2 can be adjusted in the Mission Editor to any desired ILS beacon. By default it is set to 38 MHz.**



**Figure 84: AFN-2 Homing Indicator**

The marker lamp in the center of the indicator will light when flying over aerodrome's near and far NDBs.

As the AFN-2 is a very sensitive instrument, special care to reduce vibrations is used when the indicator is installed in the Bf 109 K-4. It is installed into a separate aluminum sheet attached to the dashboard with rubber screws. This makes the device provide more reliable input; however strong vibrations can still disrupt its operation.

## Repeater Compass

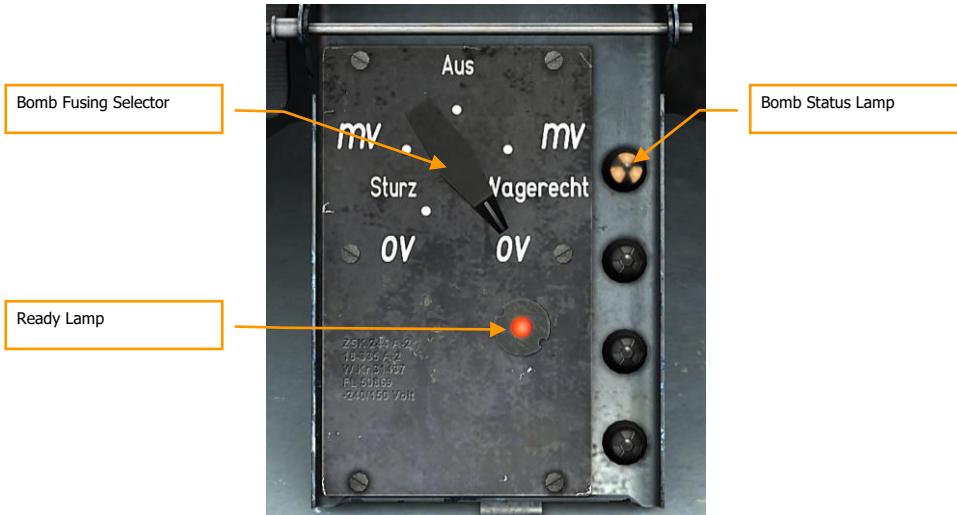
The Repeater Compass consists of a rotary compass rose, a current magnetic heading pointer, and a desired heading reference stripe.



**Figure 85: Repeater Compass**

The aircraft symbol with pointer rotates as the aircraft's heading changes. The compass rose can be rotated with the bezel to set the desired magnetic heading.

## Bomb Control Panel



**Figure 86: Bomb Control Panel**

The "Zünderschaltkasten 244A" Bomb Control Panel installed in the Bf 109 K-4 is a standard device used on many Luftwaffe aircraft.

The Bomb Control Panel is very simple in operation. It controls the amount of electrical charge sent from the battery to the bomb fuse. Depending on the Bomb Fusing Selector position, different fusing situation is ensured.

- The Sturz settings on the left-hand side are used for dive bombing.
- The Wagerecht settings on the right-hand side are used for level bombing.
- The OV settings stand for Without Delay, which means the bomb explodes immediately upon contact with the ground.
- The MV settings stand for With Delay, which means the bomb explodes after a short delay upon impact.

Therefore, the selector should be set in advance before the bombing run for proper attack profile. Also should ensure that V10 circuit breaker is on.

Generally, OV settings are to be used for bombs dropped from higher altitudes, while MV settings are used for low-altitude bombing to allow the attacker to clear the blast area.

The Bomb Status Lamp indicates that bomb is suspended. Bf 109 can carry up to 4 bombs on the hardpoint under fuselage.

Red Ready Lamp indicate the armed fuse of bombs and readiness to release.

## Left Side Controls

### Canopy Handle, MW/Fuel Selector Handle and Tail Wheel Lock Handle

The additional internal tank located behind the pilot's seat can be used alternatively to store the MW 50 mixture, or conventional aviation fuel, in essence providing extra range at the expense of available extra power.

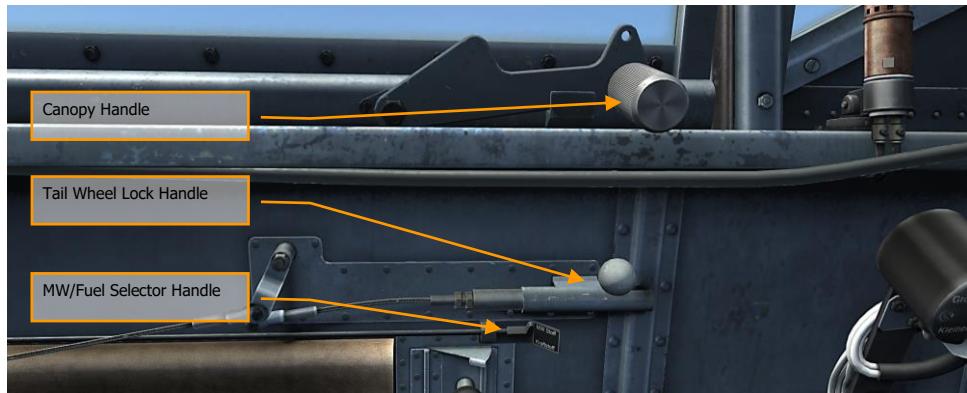
The MW/Fuel Selector Handle is used to set the MW 50 tank status. Normally, it is set on the ground before the engine is started, according to the filled liquid, and left alone for the duration of the flight.

Please note that incorrectly setting this switch can have catastrophic results, by either feeding the water-methanol mixture into the fuel lines, or spraying aviation fuel into the supercharger.

The liquid type (MW or fuel) can be assigned via Mission Editor in the specify Additional Properties tab of player's aircraft panel.

**NOTE!** The liquid will be filled in this auxiliary tank if the fuel in the main tank is set not less 100 liters (34%) in the ME.

The pump in the auxiliary tank is low-output device. Therefore the pumping of fuel from auxiliary to main tank request about half an hour and depends of motor's manifold pressure.



**Figure 87: Canopy Handle, MW/Fuel Selector Handle and Tail Wheel Lock Handle**

The tail wheel on the Bf 109 K-4 can be locked in the center position, or allowed to rotate freely.

- Unlock the tail wheel for taxi.
- Lock the tail wheel for take-off and landing.

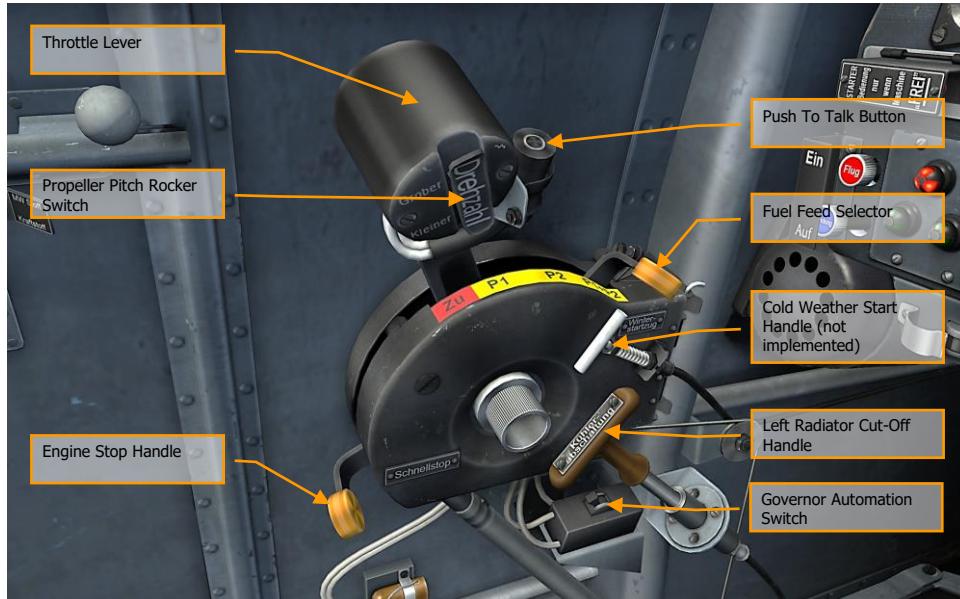
The canopy crank can be used to open or lock the canopy.

## Throttle Quadrant

The **Throttle Lever** is used to set the desired supercharger pressure by opening and closing the throttle butterfly of the engine.

When Prop Pitch Automation is enabled, moving the Throttle Lever also automatically adjusts the Prop Pitch as needed.

The Throttle Lever should be moved according to desired supercharger pressure (shown on the Supercharger Pressure Gauge to the right of the front dashboard, the gauge labeled ATA).



**Figure 88: Throttle Quadrant**

A **Fuel Feed Selector** located below the throttle lever is used to switch between the aircraft's fuel pumps.

Two fuel pumps are provided with the engine, "P1" and "P2" that draw fuel from the L-shaped fuel tank.

The following options are provided:

- "ZU" (both off)
- "P1" (P1 pump on)
- "P2" (P2 pump on)
- "P1+P2" (both pump on)

Fuel from drop tank feeds into the main tank via pressurization system.

While the propeller pitch is controlled automatically, a manual override is also provided.

The propeller pitch can be manually overridden via **Governor Automation Switch** located alongside the throttle lever. The switch is normally set to the lower (Automatic), but can be manually set to the upper (Manual) position. That enables the "Drehzahl" Propeller Pitch Rocker Switch on the throttle lever.

It is recommended to keep the Governor Automation Switch in the Automatic position during normal engine operation, and only switch to manual in case of an emergency.

The "Drehzahl" **Propeller Pitch Rocker Switch** on the throttle lever can be used to manually change propeller pitch when the propeller automation is switched off. Then, the "Drehzahl" rocker switch on the throttle can be moved to "Größer" (Higher RPM) or "Kleiner" (Lower RPM). Holding the thumb button in one of these positions continues to modify the prop pitch for as long as the button is depressed, and until the limit is reached. Therefore, this switch can be used to feather the propeller.

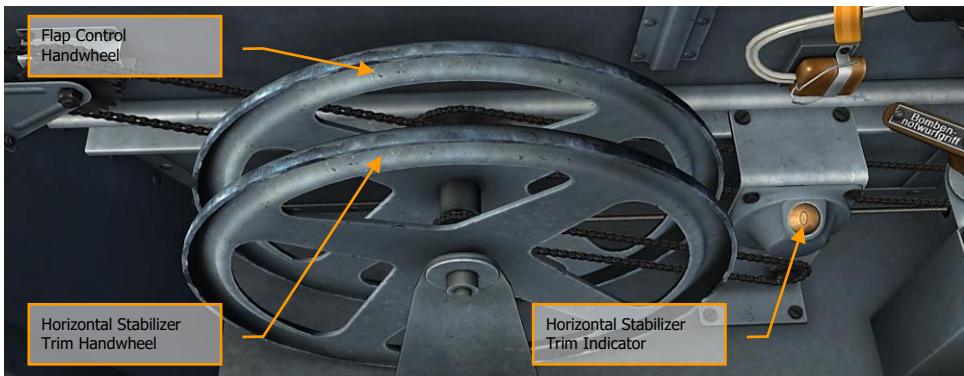
The **Engine Stop Handle** is used to shut off the engine upon landing.

After landing, run the engine for about 2 minutes to allow it to cool; otherwise shutting off the engine runs the risk of engine damage. Return the lever down when the engine stops.

In the event of an emergency, damaged of collant system, when the normal automation does not lead to desired results, the **Radiator Cut-Off Handle** can be used to cut off the corresponding radiator.

Please note that a matching Right Radiator Cutt-Off Handle is also located on the right side of the cockpit.

## Flap Control and Horizontal Stabilizer Trim Handwheels



**Figure 89: Flap Control and Horizontal Stabilizer Trim Handwheels**

The **Flap Control Handwheel** controls the landing flap position. In the bank of two handwheels, the Flap Control is the one on the left.

- To raise the flaps, rotate the wheel counterclockwise.
- To lower the flaps, rotate the wheel clockwise.

The flaps are mechanically linked to the wheel. The wheel will not rotate once the limit position is reached. There is no cockpit indicator of flap position.

The **Horizontal Stabilizer Trim Handwheel** is used to mechanically set the rotation angle for the adjustable horizontal stabilizer based on changing trim conditions.

In the bank of two handwheels, the Horizontal Stabilizer Trim Control is the one on the right.

Use the provided **Horizontal Stabilizer Trim Indicator** to monitor actual stabilizer position. The indicator shows the current position of the adjustable Horizontal Stabilizer.

The gauge is graduated from -6 to +2 degrees of horizontal stabilizer rotation. The scale is to 1 degrees throughout. The normal position is indicated by 0.

## Ordinance Emergency Release and Fuel Priming Pump Handles

The **Ordinance Emergency Release Handle** jettisons any attached fuselage load, such as the drop tank or the underfuselage bomb.

Pull out the handle to jettison any fuselage load.



**Figure 90: Ordinance Emergency Release and Fuel Priming Pump Handles**

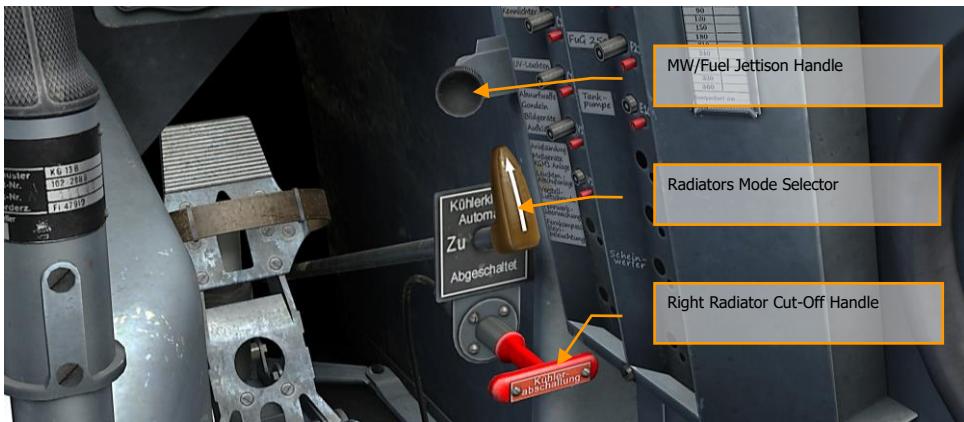
The **Fuel Primer Pump Handle** is used to prime the engine with fuel. The handle must be pumped manually to execute a prime. When the primer handle is pumped, the pump fills the injection apparatus.

A few pumps are usually needed to prime a cold engine. One is usually sufficient for a warm engine.

The engine should be primed only when it is turning over.

## Right Side Controls

### MW/Fuel Jettison Handle and Radiators Mode Selector



**Figure 91: MW/Fuel Jettison Handle, Radiators Mode Selector and Right Radiator Cut-Off Handle**

Pull the **MW/Fuel Jettison Handle** to begin dumping fuel or MW mixture from rear auxiliary tank.

In the event of an emergency, or in unusual flight conditions when the normal automation does not lead to desired results, the Radiator Automation may be disabled with the use of the **Radiators Mode Selector**.

The four possible settings are:

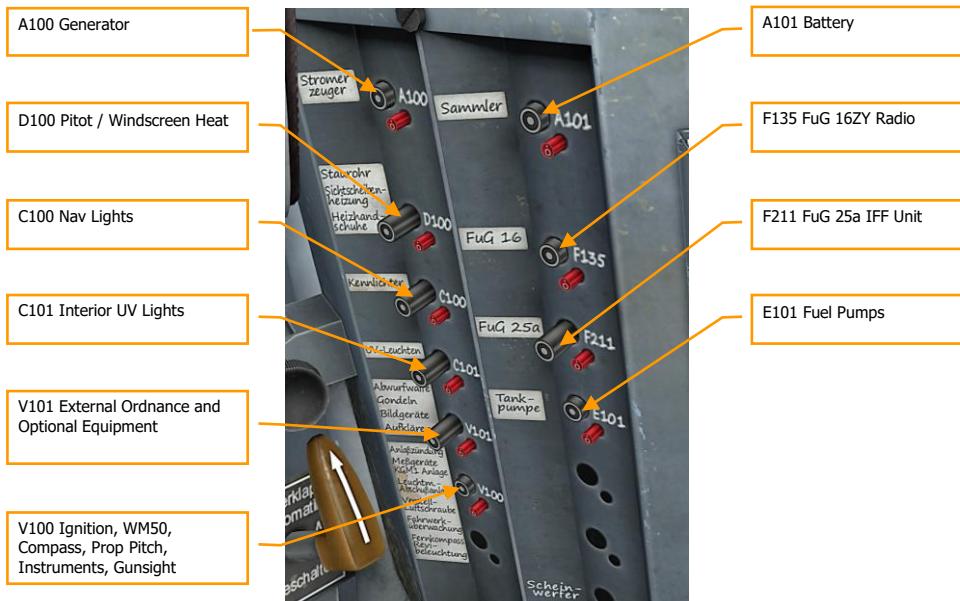
- "Automatik" (Auto) Up - Automation is ON.
- "Zu" (Closed) Left - Automation is OFF. Radiator flaps are closed.
- "Auf" (Open) Right - Automation is OFF. Radiator Flaps are open.
- "Abgeschälter" (Off) Down - Automation is OFF. Radiator flaps remain fixed to current position.

## Circuit Breaker

The circuit breaker is used to control various electrical functions. It consists of two rows of circuit breakers.

Each circuit breaker has two buttons. The larger black button with a white dot switches the corresponding circuit on. Red button opens the circuit and switches it off.

Each circuit is designed to pop out if it is overloaded and can be reset by pushing the larger black button back in.



**Figure 92: Circuit Breaker**

The left-most row of buttons is used to control various internal systems.

The right-hand row of buttons is used to control the radio system as well as the electrical fuel pump.

The fuel pump and all other devices are enabled as soon as the corresponding button is depressed.

The following buttons are provided:

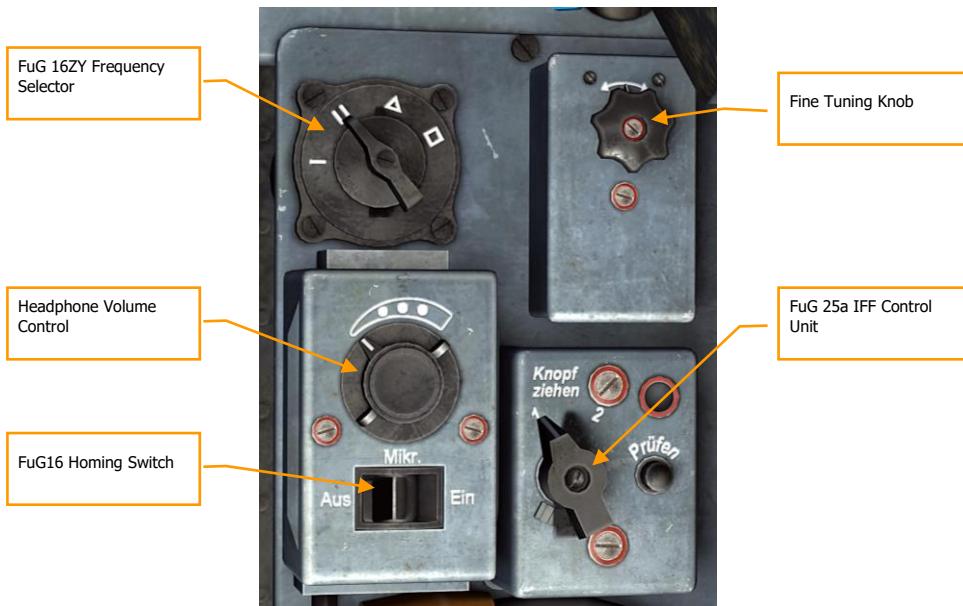
A100	Stromerzeuger	24V 2000W Generator
D100	Staurohr Sichtscheibenheizung Heizhandschuhe	Pitot Heater Window Heating Heated Gloves

C100	Kennlichter	Exterior Nav Lights
C101	UV-Leuchten	Interior UV Lights
V101	Abwurfwaffe Gondeln Bildgeräte AufklärerL Messgeräte	External Ordnance and Optional Armament Gun or Recon Camera Instruments
V100	KGM1 Anlage Verstell-Luftschraube Fahrwerküberwachung Fernkompass Revibeleuchtung Anlasszündung	MW-50 System Prop Pitch Automation Landing Gear Indicator Compass REVI Illumination Ignition
A101	Sammler	24V, 7.5 Ah Battery
F135	FuG 16	FuG 16 Radio
F211	FuG 25a	FuG 25a IFF Unit (not implemented)
E101	Tankpumpe	Fuel Pumps

## FuG 16ZY Controls

The FuG 16ZY Control panel has the following five controls:

- FuG 16ZY Frequency Selector
- Headphone Volume Control.
- FuG 16 Homing Switch.
- Fine Tuning Knob.
- FuG 25a IFF Control Unit (not implemented)



**Figure 93: FuG 16ZY Controls**

### FuG 16ZY Frequency Selector

The Frequency Selector for the FuG 16ZY radio has four positions indicated by symbols. All four positions are locked to specific frequencies before flight. The pilot cannot manually set frequencies beyond the four presets.

The four frequencies are used for communication with increasingly larger groups of aircraft.

The I position is for Y-Führungs frequenz, or Management frequency, is used for communication within the flight or squadron.

The II position is for Gruppenbefehls frequenz, or Group Order frequency, is used to communicate between several flights from different squadrons participating in a single raid.

The  $\Delta$  position is for Nah-Flugsicherungsfrequenz, or the Air Traffic Control frequency. It is used to communicate with the designated Air Traffic Controller.

The  $\square$  position is for Reichsjägerfrequenz, or Reich Fighter Defense Frequency, and is used to coordinate country-wide air defense efforts in large scale raids.

### Headphone Volume Control

The Headphone Volume Control is used to adjust headphone volume. Turning the knob clockwise increases volume; turning the knob counterclockwise decreases it.

### FuG16 Homing Switch

The Homing Switch can be set to one of two positions, FT FT (Funkturm or Radio Tower) and Y ZF (Zwischenfrequenz or Intermediate Frequency).

This works in conjunction with the FuG 16ZY Frequency Selector and determines the radio set operation.

Please see the below table for details.

<i>Homing Switch</i>	<i>Freq</i>	<i>Push-to-Talk Open</i>	<i>Push-To-Talk Depressed</i>	<i>Transm</i>	<i>Recv</i>
<b>FT FT</b>	I	Listen	Talk	I	II
<b>Y ZF</b>	I	E-Meßbetrieb Listen	E-Meßbetrieb Listen+Talk	I	II
<b>FT FT</b>	II, $\Delta$ or $\square$	Listen	Talk	II, $\Delta$ or $\square$	
<b>Y ZF</b>	II, $\Delta$ or $\square$	Listen to AFN-2 Targeting	Talk	II, $\Delta$ or $\square$	

### Fine Tuning Knob

The FBG 16 Fernbediengerät (remote control unit) Frequency Selector is used for fine frequency adjustment within a selected preset.

### Oxygen Flow Indicator

The Oxygen Flow Indicator shows the flow of oxygen as it is inhaled and exhaled by the pilot. When the pilot inhales, the blinkers open as oxygen is moved through the system. As the pilot exhales and oxygen stops flowing, the blinkers close.



**Figure 94: Oxygen Flow Indicator**

## Oxygen Pressure Gauge

The Oxygen Pressure Gauge is located on the bottom right corner of the instrument panel and indicates pressure in the oxygen system. The gauge measures pressure in kilograms per square centimeter ( $\text{kg}/\text{cm}^2$ ). The instrument is graduated from 0 to 250  $\text{kg}/\text{cm}^2$  and scaled to 10  $\text{kg}/\text{cm}^2$ . Normal full pressure of the system is 150  $\text{kg}/\text{cm}^2$ . In normal working conditions, oxygen pressure should decrease by no more than 10  $\text{kg}/\text{cm}^2$  after 20 minutes of operation.

Note that the oxygen pressure readings can drop as altitude increases due to the cooling of the oxygen tanks. Conversely, the pressure can increase as altitude decreases due to the warming of the tanks. A rapid decrease of oxygen pressure in level flight or during a descent is abnormal and may indicate an oxygen system leak or malfunction.



**Figure 95: Oxygen Pressure Gauge**

## Oxygen Flow Valve

The Oxygen Flown Valve is used to turn the flow of oxygen to the pilot.

When the flow valve is opened, the oxygen is first sent to the Oxygen Regulator located on the right side of the cockpit, just behind the pilot seat. The oxygen regulator has a diaphragm which actuates a valve, permitting oxygen to flow through the regulator, where it mixes with free air in varying amount in accordance with barometric pressure.



**Figure 96: Oxygen Flow Valve**

## Drop Tank Fuel Transfer Monitor

A transparent portion of the fuel line is provided allowing the monitoring of the fuel supply.

When drop tanks are used, visible fuel flow should be apparent in the transparent section. If no fuel is pumped, the drop tank has been exhausted, or a malfunction has occurred.



**Figure 97: Drop Tank Fuel Transfer Monitor**

# FLIGHT CHARACTERISTICS



# FLIGHT CHARACTERISTICS

## General Characteristics

The Bf 109K-4 is generally a very well-handling aircraft. It is light on all of the controls and stable at all normal loadings. Light, steady pressure on the controls is sufficient to execute any routine maneuver. At various speeds in level flight or in climbing or diving, the control pressures required are slight and can be stabilized by adjustments on the trim tabs.

The aircraft has a redline speed of 850 km/h Indicated Airspeed (IAS), with a maximum diving engine RPM of 2,600. Extra caution should be used not to attempt steep dives at low altitudes as the aircraft accelerates very rapidly, and requires considerable stick force to pull out of any dive.

The aircraft is susceptible to high speed stalls, but not any more so than any other high speed aircraft. A buffeting of the tail section occurs about 5 to 10 km/h above the stall. All that is necessary to recover from a high speed stall is to release the back pressure on the stick and then recovery is almost instantaneous.

Recovery from a normal stall is the same. The buffeting, however, occurs at about 5 to 10 km per hour above the stall.

The aircraft is generally normal in its flying characteristics. When trimmed for normal cruising speed, the aircraft will become nose-heavy when the nose is raised and the airspeed drops. Under the same cruising conditions, if the nose is lowered and the airspeed increases, the aircraft will become tail heavy in direct proportion to the airspeed.

- When you lower the flaps, the airplane becomes nose heavy.
- When you raise the flaps, the airplane becomes tail heavy.
- When you retract the landing gear, the airplane becomes tail heavy.

# Operating Data

**Fuel:** B 4 with MW-50

**Tank contents:**

**Fuel:** Main Tank: 400 Liters

Drop Tank: 300 Liters

**Oil:** 50 liters + 6.5 liters of lubricant air space

**MW-50:** 118 Liter tank can be filled with 75 l of MW-50 mixture of 118 l of fuel

**Max airspeed w/ extended landing gear:** 350 km/h

**Max airspeed w/ extended flaps:** 250 km/h

**Cruise Parameters (with climb and combat power):**

**RPM (manual prop pitch, 12 O'clock):** 2,400 – 2,450

**RPM (auto prop pitch):** 2,550 – 2,600

**Boost pressure (manual prop pitch, 12 O'clock):** 1.45 ATA

**Boost pressure (auto prop pitch):** 1.45 ATA

**Fuel pressure:** 1.6 – 1.8 kg/cm<sup>2</sup>

**Max Oil pressure:** 9.5 kg/cm<sup>2</sup>

**Operating Data in Flight:**

**Maximum dive RPM:** 2,850

**Min Oil Pressure:** 3.5 kg/cm<sup>2</sup>

(at 2600 RPM and 70 to 80° C oil temperature at best performance altitude in horizontal flight)

**Oil Temperature (inlet):**

Minimum: 30 ° C

Normal: 70 – 85 ° C

Maximum (briefly): 95 ° C

**Maximum Coolant Temperature (for no more than 10 minutes):**

Below 5.5 km: 115 ° C

Above 5.5 km: 102 ° C

# Operating Limits

## Load Factor Limitations

Standard RLM system classified all Luftwaffe aircraft by their Usage Group (Verwendungsgruppe) and their Stress Group (Beanspruchungsgruppe)

The following Usage Groups were designated:

H	High-performance and experimental
G	Commercial Transport
P	Commercial Passenger
R	Travel and private
S	Trainer
K	Aerobatic

The following Stress Groups were designated:

Group 1	Very Low
Group 2	Low
Group 3	Normal
Group 4	High (Aerobatic)
Group 5	Very High (Aerobatic)

The Bf 109K-4 is listed with the Usage Group (Verwendungsgruppe) H and Stress Group 4 or 5, depending on loadout.

The structural load limit for the Bf 109 K-4 is roughly within +8G and -4G. However no cockpit G-force indication is provided, and light construction combined with large control forces required to pilot the aircraft at higher speeds generally mean that overloading the airframe is unlikely under most conditions.

Undue stress on the airframe is generally only possible when pulling out of a high-speed dive.

Not using full stick deflection during dive pull-out is generally the only precaution needed to avoid overstressing the airframe.

## Engine Limitations

The maximum diving engine overspeed is 2,800 RPM. Avoid operation below 600 RPM.

## Airspeed Limitations

The FI 22234 Airspeed Indicator used in the Bf 109 K-4 shows Indicated Air Speed. As such, maximum allowable airspeed as shown by the Indicator depends on current altitude.

Maximum permissible airspeed is generally only attainable in a dive.

Using droptanks, underwing gondolas, or other Rüstsatz, has a significant effect on maximum permissible airspeed.

### **Max Dive Speeds (with FI 22234 Airspeed Indicator) in km/h:**

Alt (km)	W/ or W/O wpn gondolas	W/ other Rüstsatz
11	400	400
9	500	500
7	600	600
5	700	700
3	800	700
1	850	700

Do not exceed the following flap and landing gear setting airspeed restrictions:

**Max airspeed w/ extended landing gear:** 350 km/h

**Max airspeed w/ extended flaps:** 250 km/h

## Instrument Markings

The Bf 109K-4 is equipped with limit placards and gauges color-coded with operating limit information on some of the gauges. Usually, a set of two limiter arrows show normal operating limits.

For gauges not so marked, all relevant information must be memorized by the pilot, or referenced from this Pilot's Operating Handbook.

## Compressibility

Compressibility effects result in a loss of control over the aircraft as it approaches the speed of sound and is the reason maximum IAS is reduced as altitude increases. The lift characteristics of the aircraft are largely destroyed and intense drag develops. The stability, control, and trim characteristics of the aircraft are affected. The tail buffets or the controls stiffen, or the aircraft develops uncontrollable pitching and porpoising, or uncontrollable rolling and yawing, or any combination of these effects. If the speed of the aircraft is allowed to increase out of control in a dive, either the terrific vibrations of the sound barrier shockwaves cause structural failure or the aircraft crashes while still in the compressibility dive.

In the Bf 109K, the first effect of compressibility is a “nibbling” of the control stick, where it occasionally jumps slightly in the pilot’s hand. If the airspeed is allowed to climb, this movement will increase into a “walking” stick, where it moves uncontrollably forward and back, resulting in the characteristic “porpoising” pitching moments of the aircraft. As the airspeed builds, this effect will become increasingly violent.

To avoid compressibility effects in a dive, it’s critical that a dive is entered at a safe airspeed for the altitude and that airspeed is monitored carefully during the dive. Please refer to the Max Dive Speeds table above for more information.

## Glides

The Bf 109K can be glided safely at speeds down to about 10 km/h above stalling speed. With average loads, this will be around 200 km/h IAS at any level – this speed increasing with the weight of the aircraft. The optimum power-off gliding speed is 220 to 230 km/h.

With the landing gear and flap retracted, the glide flight path is fairly flat. In this condition, however, the nose is held high and forward visibility is poor. Lowering either the flaps or the landing gear reduces the safe gliding speed and greatly steepens the gliding angle and increases the rate of descent.

When changing direction in a glide, refer to the table below for the list of possibilities.

Altitude (m)	Max Change Of Direction
100	10 °
200	20 °
300	40 °
400	60 °
500	80 °

## Stalls

A stall occurs when the aircraft is unable to generate sufficient lift for controlled flight, usually on one or both wings. This results in a loss of control to various degrees, leading to a possible wing-over or an uncontrolled spin in the worst case. The Bf 109K stalling characteristics are generally mild and recoverable. In general, a stall is preceded by airframe buffeting. Stalling speeds vary greatly depending on the gross weight and the external loading of the aircraft. Lowering the flaps and landing gear reduces stall speeds considerably.

Recovery from a stall on the Bf 109K is normal. In early onset, simply releasing the stick and rudder to drop the nose will recover control. If a wing-drop condition occurs, applying opposite rudder and releasing the stick will recover control.

## Spins

### Power-off Spins

In general, spins in the Bf 109K are uncomfortable, because of heavy oscillations. Occasionally, the left spin oscillations will dampen out after approximately three turns, but the right spin oscillations will not. When controls are applied to start a spin, the aircraft snaps one-half turn in the direction of the spin, with the nose dropping to near vertical. At the end of one turn, the nose rises to or above the horizon and the spin slows down, occasionally coming almost to a complete stop. The aircraft then snaps one-half turn with the nose dropping to 50-60 degrees below the horizon and continues as during the first turn. The force required to hold the controls in the spinning position is quite heavy, and some rudder buffet becomes noticeable. When controls are applied for recovery, the nose drops to a near vertical position and the spin speeds up and then stops in one to 1 and 1/4 turns.

### Power-off Spin Recovery

Recovery procedure is the same in both a left and a right spin. As soon as opposite rudder is applied, the nose drops slightly. The spin speeds up for about 1 and 1/4 turns and then stops. The rudder force is light at first, becomes very heavy for about one second in the first one-half turn, and then drops to zero as the spin stops. Recovery is affected in the normal manner as follows:

- Controls with spin.
- Apply full opposite rudder.
- Stick neutral after the aircraft responds to rudder (as rotation stops)
- Rudder to neutral and complete recovery as spin ends.

### Power-on Spins

Power-on spins should never be intentionally performed in the Bf 109K. In a power-on spin, the nose of the aircraft remains 10 to 20 degrees above the horizon, and recovery control has no effect upon the aircraft until the throttle is completely retarded.

## Power-on Spin Recovery

Close throttle completely and apply controls as for power-off spins recovery. Hold full opposite rudder with stick in neutral until recovery is affected. As many as five or six turns are made after rudder is applied for recovery, and 1,000 meters or more of altitude are lost.

## High Performance Maneuvers

The Bf 109K offers exceptional aerobatic qualities; stick and rudder pressures are light and the aileron control is excellent speeds up to 300 km/h. At higher airspeeds, control forces required become considerable; however in capable well-trained hands the Bf 109 is a powerful dogfighter that rivals any other contemporary fighter. The primary safety consideration for any high performance maneuver is altitude.

The aircraft is capable of performing chandelles, wingovers, slow rolls, loops, Immelmans, and split-S turns with ease. However, remember that inverted flight must be limited to 10 seconds, because of loss of oil pressure and failure of the scavenger pump to operate in an inverted position.

When performing a loop, the nose of the aircraft needs to be pulled over the top, as it may not do so by itself. Without pulling pressure on the stick, the aircraft has a tendency to climb on its back.

The aerodynamic characteristics of the Bf 109K are such that snap rolls cannot be satisfactorily performed. Attempting to snap roll the aircraft aggressively may result in a power spin.

## Instrument Flying

The Bf 109K-4 is generally not intended for instrument flying. While ostensibly equipped with most cockpit instrumentation required for instrument flying, the Kurfürst is a simpler WWII-era aircraft designed for daylight VFR flying.

## Altitude Control

The rate of climb or descent, at a given airspeed and power setting, is determined by the degree of pitch, or nose attitude change. At high speeds, a very slight change in pitch will immediately result in a high rate of climb or descent, with a rapid gain or loss of altitude. Therefore, when maneuvering at low altitude under instrument conditions, as during an instrument approach, the primary rule of safety is: keep the airspeed down.

## Bank Control

The turn needle is gyro-actuated and indicates rate of turn only, regardless of speed. Therefore, at a given rate of turn, the angle of bank in a coordinated turn depends upon true airspeed. A standard-rate turn at an altitude of 1,000 m and an IAS of 400 km/h will require approximately 30° of bank. But at an IAS of 450 km/h will require about 33° of bank to accomplish a standard-rate turn.

Control pressure on the elevators changes rapidly during the entry into a steeply banked turn, and it's very easy at this time to make inadvertent changes in your pitch. As explained above, these slight changes in nose attitude, at high speeds, will result in large altitude variations; these can be critically dangerous when flying on instruments and close to the ground. This hazard can also be avoided by

keeping the airspeed low. When airspeed is low, the angle of bank required for a given rate of turn is greatly lessened and the problem of control is proportionally reduced.

## Control Sensitivity

Given the sensitivity of the Bf 109 K-4's controls, it is essential to remain mentally attentive to the instruments at all times. Accurate trim control is extremely important; it will contribute greatly to physical relaxation and make it easier to concentrate on the numerous unrelated details of instrument flight. Trimming should be done carefully and as often as required.

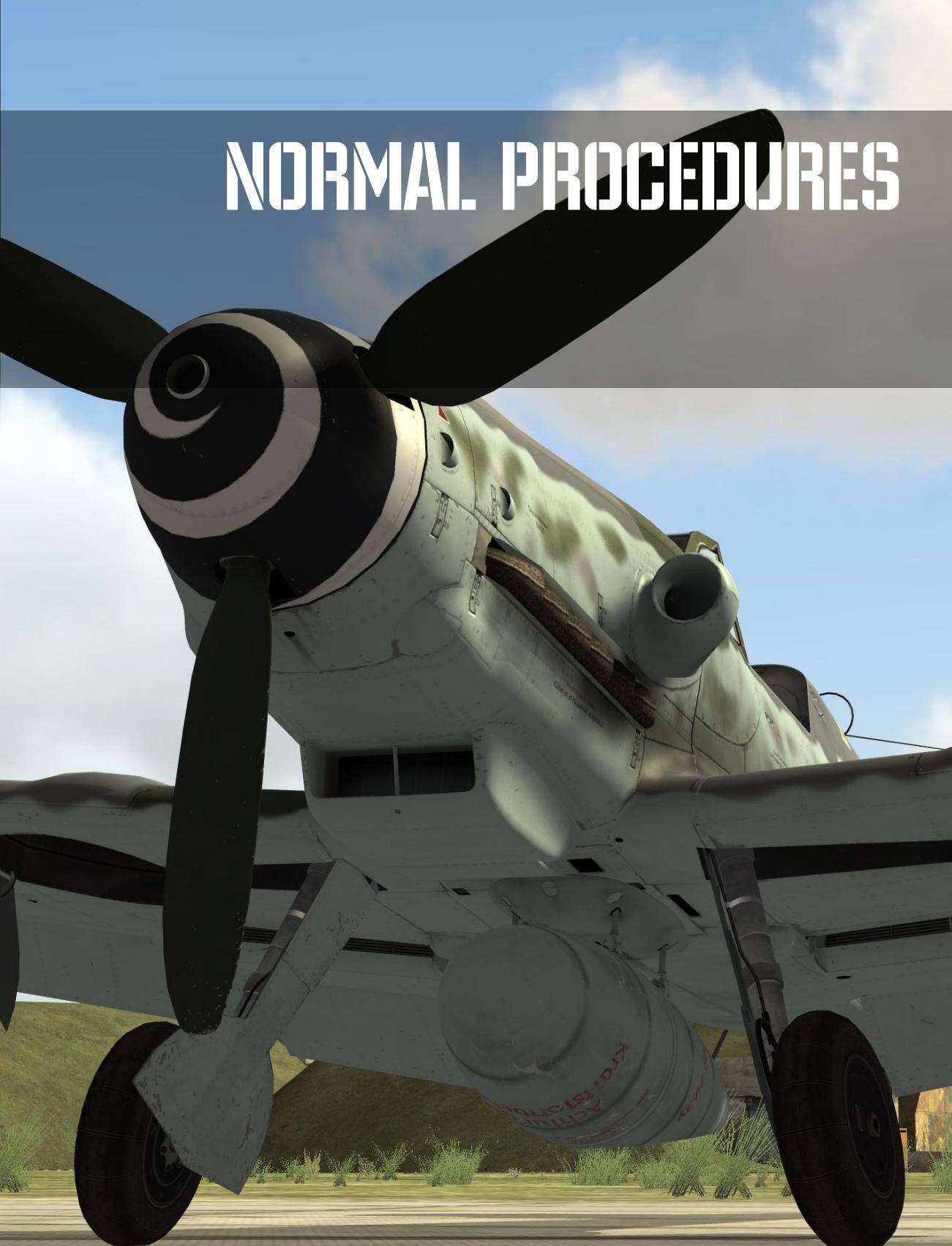
## Instrument Approach

Shortly before reaching the station on the initial approach, airspeed is reduced to 220 km/h Indicated and flaps are lowered to 20°. Keeping the airspeed low simplifies radio procedures and increases control of the aircraft.

After completion of the initial approach, final approach is performed at 180 km/h Indicated, with landing gear down and flaps set to 40°.

Although final approach speed depends largely on ceiling conditions, 220 km/h with 40° of flaps is recommended.

# NORMAL PROCEDURES



# NORMAL PROCEDURES

## Normal Start-Up

### Start-Up

As soon as you enter the cockpit, make sure that the Ignition Selector is in "0" (Off), and the Fuel Pumps Selector is set to "Zu" (Off).



Then make sure chocks are properly placed; a fire extinguisher is ready at hand and the aircraft is facing upwind.

You are now ready to start the engine.

- Close canopy.
- Turn on A100 Generator and V100 circuit breakers on the Circuit Breaker panel.
- Turn the Governor Automation Switch to upper manual position.

Move the Propeller Pitch Rocker Switch on the throttle lever back and forth.



Verify the Prop Pitch Indicator moves accordingly. Stop the propeller in the 12:00 position.

Prop Pitch Indicator



Turn the Governor Automation Switch to lower automatic position. The Prop Pitch Indicator should automatically advance to 12:30.

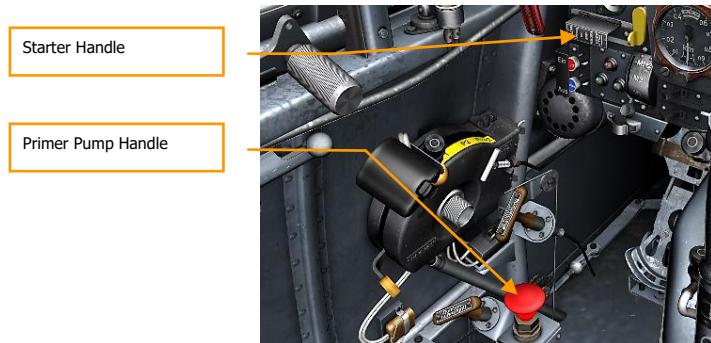
If the propeller pitch indicates otherwise, the battery should be replaced. If battery replacement is impossible, the Governor Automation Switch must be held Manual when below 1,900 RPM.

- With left hand, pump the Primer Pump Handle; this could take up to 15 strokes. When finished, secure the Handle in the down position.
- Set Pumps Selector to "P1 + P2".
- Set throttle lever a bit from 0% position.
- Set Radiator Mode Selector to "Auf" (Open).

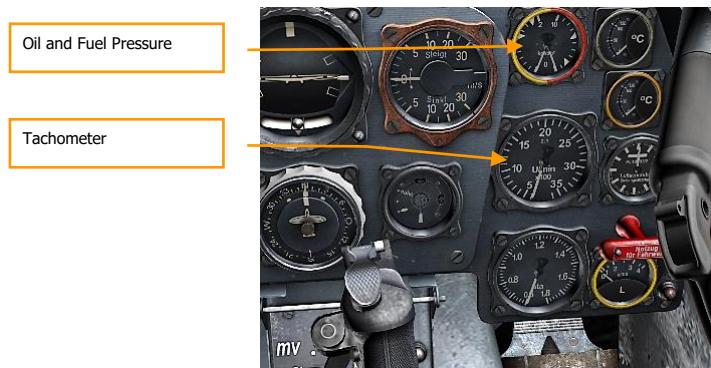
Radiator Mode Selector to "Auf" (Open)



- Enable electrical fuel pump with E101 circuit breaker.
- Signal the ground crew technicians to start cranking up the inertial starter. To do so, bring up the communications menu ("\ by default), select ground crew as recipients ("F8"), and issue the order to run the starter ("F4"). The ground crew will respond if they have a man ready.
- Wait for "Frei" ("Clear!") report (it usually takes about 20 second to complete), and then set the Ignition Selector Switch to "M1 + M2".
- Raise the Starter Handle Cover and pull the Starter Handle. Watch the Fuel Pressure Gauge and operate the Primer Pump if fuel pressure drops below 0,8 bar.

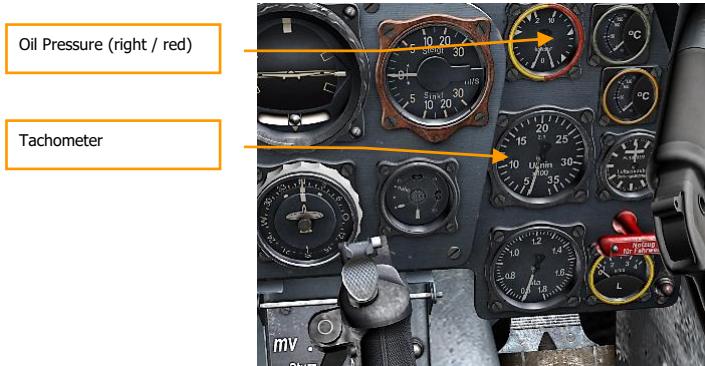


- As soon as the engine starts firing, release the Starter Handle.
- Check that the Tachometer indicates no more than 600 RPM. Close the Started Switch Cover.
- Check Fuel and Oil Pressure gauge. Needles must move and indicate some pressure within 10 seconds of engine start. If not, shut down the engine immediately and check for leaks.



## Warm-up

- Maintain no more than 600 RPM for 20 to 40 seconds after starting the engine.
- Gradually increase RPM until oil pressure reaches no more than 9.5 kg/cm<sup>2</sup>.



- Continue checking the Fuel and Oil Pressure gauge for sudden changes in oil pressure. If any sudden pressure changes are noted, shut down the engine immediately and check for leaks
- Continue checking all engine gauges: Coolant Temperature; Oil Temperature; Prop Pitch Indicator; Tachometer; Supercharger Pressure Gauge; and Fuel Contents Gauge.



- Check the fuel system when engine RPM is at about 2,000. Keep the Fuel Feed Selector in both P1 and P2 positions for 30 seconds. Check for sudden changes in fuel pressure or engine RPM. If any sudden changes occur, shut down the engine immediately.
- Check the Radiator Flaps by moving the Radiator Mode Selector to "Auf" and "Zu" positions, then set back to "Auf" (Open).
- Check the electrical Propeller Pitch control when engine RPM is at about 2,000.
  - Shut off the battery with the corresponding switch on the Main Circuit Breaker.

- Turn the Governor Automation Switch to upper (manual) position.



- Move the Propeller Pitch Rocker Switch on the throttle lever back and forth. Verify the Prop Pitch Indicator moves accordingly.



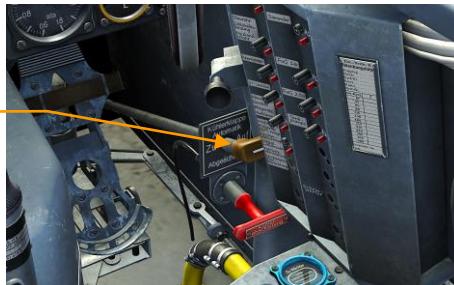
- Stop the propeller in the 12:00 position.
- Turn the Governor Automation Switch to lower (automatic) position. The Prop Pitch Indicator should automatically advance.
- Switch on the Battery Circuit Breaker to connect the battery to the electrical system.

If all checks are properly concluded, engine gauges indicate properly, and oil temperature is at least 30 ° C, you can proceed to Run-Up.

## Engine Shutdown

- Run the engine at idle for about 2 minutes to allow it to cool; otherwise engine damage may occur.
- Set Radiators Mode Selector to "Zu" (Closed).

Radiator Mode Selector to "Zu"



- Pull the Engine Stop Handle to stop the engine.

Engine Stop Handle

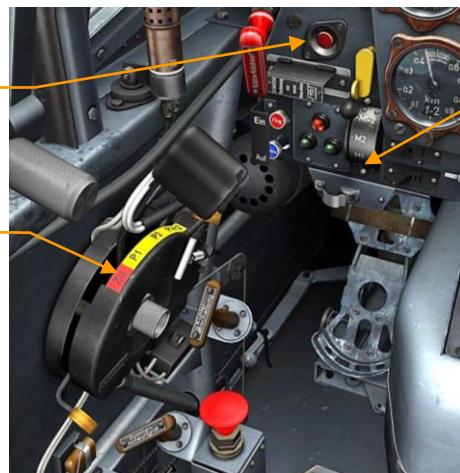


- Immediately release the Engine Stop Handle as soon as the engine stops.
- Ignition Selector Switch to "0".
- Fuel Feed Selector to "Zu".
- Press Electrical Kill Switch to electric power off.

Press Electrical Kill Switch

Ignition Selector to "0"

Fuel Feed Selector to "Zu"

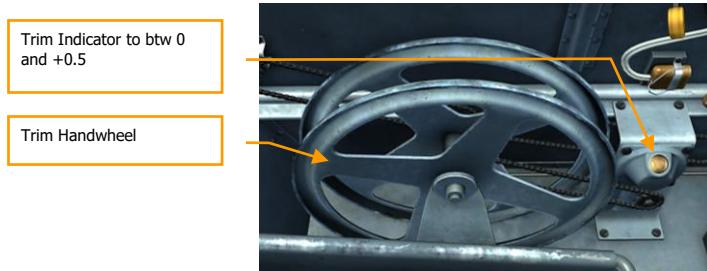


# FLIGHT

## Preparing For Take-Off

Before take-off you must check the following:

- Check that all controls move freely.
- Extend flaps and check for free aileron movement in that configuration.
- Set Horizontal Stabilizer Trim to between 0 and +0.5 °.



- Check oxygen apparatus. Turn the Oxygen Flow Valve to counterclockwise.  
Observe the Oxygen Flow Indicator to ensure the indicator blinks properly.



- Ensure Pump Selector Lever is set to "P1 + P2".
- Check Fuel Gauge indicates sufficient fuel for mission at hand.
- Check Landing Gear Position Indicator illuminates green.
- Set Prop Pitch Automation, Pitot Heat, and Exterior Lighting as needed on the Circuit Breaker panel.
- Ensure engine started as described in Start-Up section above.
- Turn on the radio set using the corresponding switch on the Circuit Breaker panel.

## Taxi

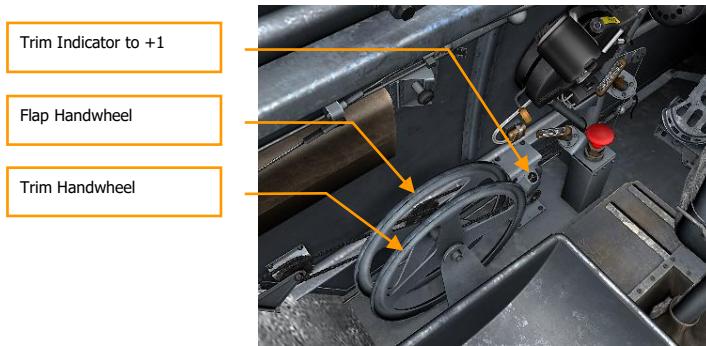
- Unlock tail wheel with the Tail Wheel Lock handle located on the left-hand side of the cockpit.



- Fully retract flaps to the 0 position. As no cockpit indication is provided, visually check actual flap position via the right-hand side exterior indicator.
- Immediately tap brakes as soon as the aircraft begins to move. Ensure brakes operate properly. Avoid holding the brakes for a long time to avoid overheating.
- When making sharp turns, increase throttle, use the brakes to steer, then reduce throttle.

## Take-Off

- For shorter runways, lower flaps to 20 °. As no cockpit indication is provided, visually check actual flap position via the right-hand side exterior indicator. 20 ° of flap is roughly four full turns of the control wheel.
- Set Horizontal Stabilizer Trim to 1 °.



- Turn the Governor Automation Switch to lower (Automatic) position. If manual prop pitch is required, ensure the Prop Pitch Indicator shows 12:00.



- Set Radiator Flap Control to Automatic.
- Ensure Oil Temperature at least 30 °C.
- Ensure Oil Pressure at least 3.5 kg/cm<sup>2</sup>

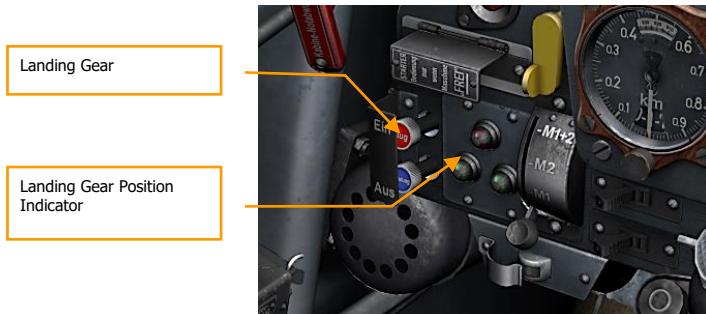


- Gradually increase throttle to take-off position (supercharger Pressure: 1.35 ATA).
- Ensure Oil Pressure does not exceed 9.5 kg/cm<sup>2</sup>.
- Tachometer: 2,300 to 2,450 RPM.
- For shorter runways, use MW boost and higher boost settings as needed (1.8 ATA).



- Proceed with take-off.
- Retract landing gear immediately upon take-off. Use the Landing Gear Controls to retract the landing gear by retracting the safety switch over the "Ein" (Up) button and pressing the button. The button remains pressed while the gear is in operation and while the gear is retracted and locked.

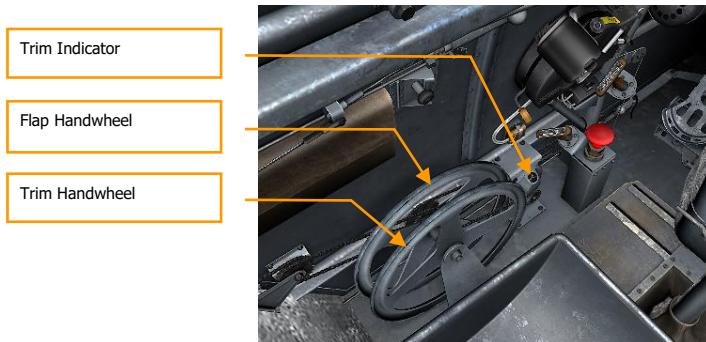
Ensure the red light illuminates on the Landing Gear Position Indicator.



If malfunction occurs during the procedure, you may attempt to press the corresponding button again.

Please note that an audible warning sound will be heard in the cockpit whenever the flaps are down while the landing gear is not in the down and locked position. This is to remind you to lower landing gear on landing, or to notify you that the gear malfunction has occurred.

- Set RPM and Supercharger Pressure to Cruise setting ( $2,400 \pm 65$ , RPM at 1.25 ATA)
- Fully retracted flaps when reaching 200 km/h.
- Use the Horizontal Stabilizer Trim Handwheel to counter resulting changes in aircraft CoG.



## Climb

- Maintain shallow climb angle until reaching 270 km/h.
- Increase climb angle and maintain 270 km/h throughout climb.

## Cruise

Please refer to the Operating Data below as well as additional data listed in the Aircraft Overview section above for information on specific guidelines and limitations.

### Cruise Parameters (with climb and combat power):

<b>Optimal Cruise Speed:</b>	420 km/h TAS
<b>RPM (manual prop pitch, 12 O'clock):</b>	2,400 – 2,450
<b>RPM (auto prop pitch):</b>	2,550 – 2,600
<b>Boost pressure (manual prop pitch, 12 O'clock):</b>	1.35 ATA
<b>Boost pressure (auto prop pitch):</b>	1.35 ATA
<b>Fuel pressure:</b>	1.6 – 1.8 kg/cm <sup>2</sup>
<b>Max Oil pressure:</b>	9.5 kg/cm <sup>2</sup>
<b>Min Oil Temperature:</b>	30 ° C
<b>Max Coolant Temperature (short-term):</b>	115 ° C

### Operating Data in Flight:

<b>Maximum dive RPM:</b>	2,850
<b>Min Oil Pressure:</b>	3.5 kg/cm <sup>2</sup>

*(at 2600 RPM and 70 to 80° C oil temperature at best performance altitude in horizontal flight)*

<b>Oil Temperature (inlet):</b>	
Minimum:	30 ° C
Normal:	70 – 85 ° C
Maximum (briefly):	95 ° C

### Maximum Coolant Temperature (for no more than 10 minutes):

<b>Below 5.5 km:</b>	115 ° C
<b>Above 5.5 km:</b>	102 ° C

- Maintain RPM and ATA as per the Operating Data table. Set RPM with throttle lever, and then monitor Supercharger Pressure. Ensure both remain within stated limits.



- Keep Propeller Pitch in Automatic mode if at all possible.

Note: if you enter a rapid dive, or advance the throttle too quickly, you risk overspeeding the engine as Propeller Pitch Automation may not react to changes quickly enough.

If descending or cruising at less than 200 km/h, keep Propeller Pitch in Manual and ensure propeller pitch is over 12:00.

When flying with Manual propeller pitch, ensure propeller pitch is properly set to produce required Supercharger Pressure for given engine RPM.

- Ensure Fuel Pressure remains within stated limits of 1.6 – 1.8 kg/cm<sup>2</sup>.
- If fuel pressure falls below 1.2 kg/cm<sup>2</sup>, turn on the Auxiliary Fuel Pump on the Circuit Breaker Panel.
- Continue to check fuel levels. Fuel Warning Light will illuminate when there enough fuel remains for approximately 20 minutes of flight in economy cruise conditions.



- If flying with drop tank, it is highly recommended to jettison it before combat by using the Fuselage Load Release handle.
- Ensure Oil Pressure and Oil Temperature are within proper Operating Limits as listed.
- Ensure Coolant Temperature is within proper Operating Limits.
- Ensure Radiator Flap Control is in Automatic mode to allow the thermostat automation to manage radiator flaps.
- In case of coolant thermostat failure or in other emergencies, you may manually manage the radiator flaps via the Control lever.

- In case of radiator damage, each radiator can be individually disconnected from the Coolant System via the Manual Coolant Valve Control levers located on corresponding sides of the cockpit.



## Diving and Descending

### Diving

- Use the Horizontal Stabilizer Trim Handwheel to trim the aircraft nose-down. Please note that considerable stick force may be required to pull out of the dive.
- Turn the Governor Automation Switch to lower (Automatic) position. Using manual prop pitch is not recommended, as it will almost certainly overspeed the engine.



- Reduce throttle to red line marking (0%)

- Maximum RPM: 2,850

Alt (km)      Never-Exceed Dive Speeds

11	400
9	500
7	600
5	700
3	800
1	850

Please note that using full stick deflection during a high-speed pull-out may overstress the airframe and lead to catastrophic damage.

### Descending

- Reduce throttle to maintain desired airspeed.
- If descending from high altitude at idle throttle, continue watching Coolant and Oil Temperature gauges to ensure the engine does not become too cold and prevent potential damage.

Oil and Coolant temperature must stay above 30 ° C



Coolant Temperature at least 30 ° C

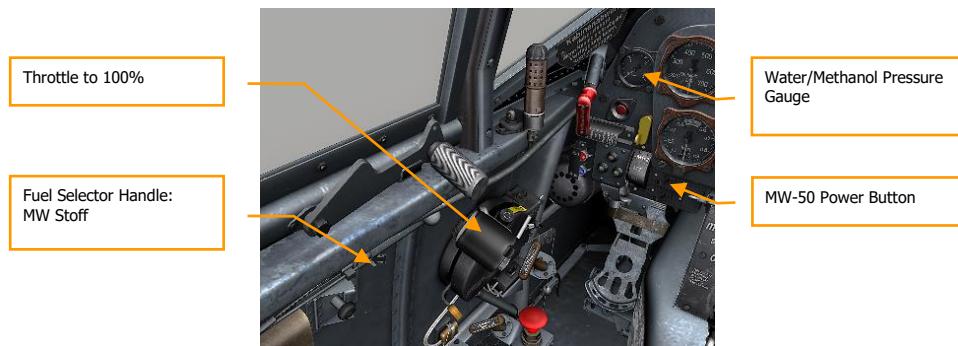
Oil Temperature at least 30 ° C

## Using the MW-50 System

The Water-Methanol injection system can add additional power to the engine. The system should be used when extra power is needed for climb or in combat.

To enable the MW-50 system, please follow the following steps:

- Ensure the Fuel Selector Handle is properly set to the upper "MW Stoff" (MW mixture) position if the MW-50 tank is filled with the MW mixture.
- Enable the MW system with the MW-50 Power Button on the main dashboard.
- Advance throttle past 100% to activate MW boost. MW-50 will not operate at lower than 100% throttle setting.



- Monitor the Water/Methanol Pressure Gauge. Ensure normal operating pressure of 0.4 – 0.6 kg/cm<sup>2</sup>
- Once MW-50 is no longer needed, turn off the mixture supply by switching the MW-50 Power Button or reduce throttle below 100%.

## Flying at Night

No special night-flying equipment is provided on the Bf 109 K-4. It is not designed for night-fighting missions; however instrument lighting and other basic features enable the aircraft to fly and navigate at night when necessary.

- Ensure your aircraft is properly serviced and prepared for night flying.
- Practice using all cockpit equipment blind prior to night flying.
- Turn on instrument lighting as needed.
- Turn on exterior lighting only when flying over friendly territory and outside the expected range of enemy night fighters.

## Landing

Jettison any external payload, such as drop tanks, bombs, or rocket pods.

Reduce speed to at least 350 km/h.

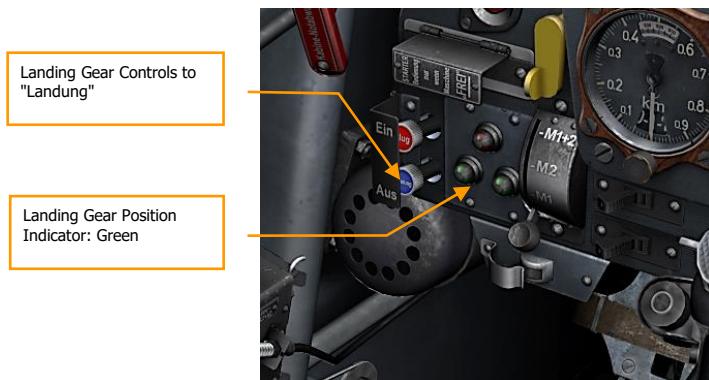
- Turn the Governor Automation Switch to lower (Automatic) position. If using Manual prop pitch, set propeller blades to 12:00 using the Propeller Pitch Rocker Switch.



- Once below 350 km/h, lower landing gear with the Landing Gear Controls. Retracting the safety switch over the "Landung" (Down) button and press the button. The button remains pressed while the gear is in operation and while the gear is down and locked. The green Aus lights also illuminate on the Landing Gear Position Indicator.

Note: never-exceed airspeed with gear down is 350 km/h.

Ensure the green light illuminates on the Landing Gear Position Indicator.



Please note that an audible warning sound will be heard in the cockpit whenever the flaps are down while the landing gear is not in the down and locked position. This is to remind you to lower landing gear on landing, or to notify you that the gear malfunction has occurred.

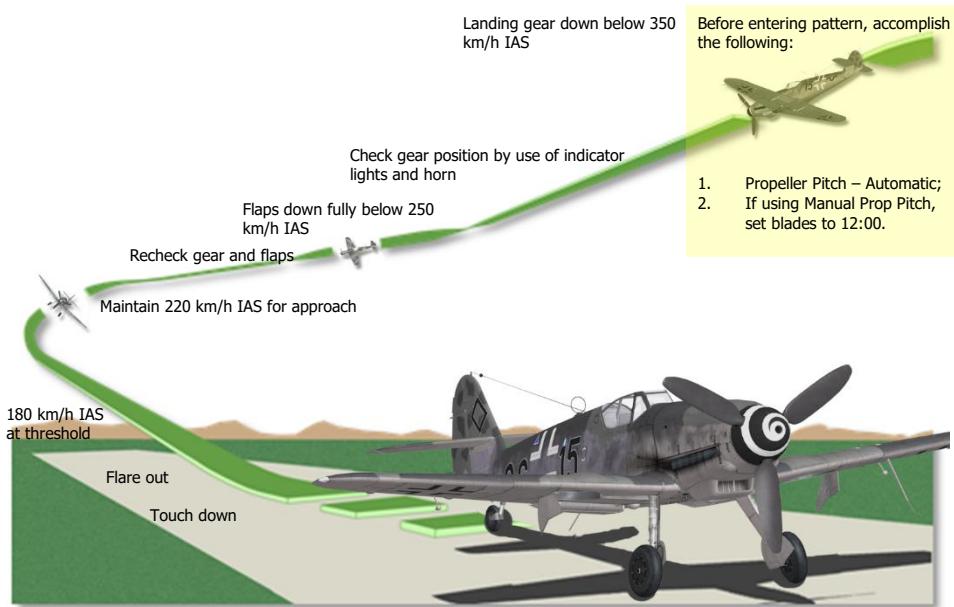
- If the landing gear does not extend automatically, you may attempt to use the following emergency procedure.
  - Retract the safety switch over the "Landung" (Down) button on the Landing Gear Controls and press the button.
  - Immediately pull the Landing Gear Manual Release handle.
  - Ensure the green light illuminates on the Landing Gear Position Indicator.
  - If the green light does not illuminate, rock aircraft wings to attempt to lock the landing gear in the down position.
- Once below 250 km/h, fully lower flaps. As no cockpit indication is provided, visually check actual flap position via the wing exterior indicator.  
Note: never-exceed airspeed with flaps down is 250 km/h.
- Use the Horizontal Stabilizer Trim Handwheel to trim the aircraft for level flight in the flaps-down configuration. Rough guideline is around the -3 position.
- Maintain 220 km/h for approach.
- Decelerate to 180 km/h at threshold.
- Touch down.
- Use brakes sparingly. Do not hold brakes for extended periods of time, as this can lead to overheating, or cause the plane to overturn.
- Unlock tail wheel with the Tail Wheel Lock handle located on the left-hand side of the cockpit.



- Raise flaps fully, or to at least 20 °. As no cockpit indication is provided, visually check actual flap position via the wing exterior indicator.
- Use the Horizontal Stabilizer Trim Handwheel to reset the stabilizer to 0 position.
- Turn off electrical fuel pump on the Main Circuit Breaker.
- Turn off the radio set using the corresponding switch on the Circuit Breaker panel.
- Follow the instructions in the Taxi sections above to navigate to your designated parking spot.

- Follow the instructions in the Engine Shutdown section above to shut down your engine once parked.

The illustration below demonstrates the landing procedure:



**Figure 98: Approach and landing procedure**

# EMERGENCY PROCEDURES



# EMERGENCY PROCEDURES

## Engine Emergencies

### Engine Overheating

Engine overheating can be recognized by one or more of the following effects: maximum coolant temperature being exceeded, or smoke coming from radiator flaps or the exhaust stacks.

An engine overheating in flight is likely caused by one of the following:

- You have been climbing at high power and below recommended airspeed. In other words, the air blast in the air scoop is insufficient. To remedy this problem, level out, reduce power and increase airspeed.
- The automatic radiator flap control not functioning properly. In this case, operate the shutters manually by means of the manual Radiator Flap Control lever located on the right-hand side of the cockpit, and watch the instruments to see if the condition has been remedied.
- The oil supply is depleted. This situation may be discovered by reading the oil pressure gauge. The engine will continue to overheat even after the flaps are opened all the way. There is no fix for this problem, so maintain the RPM and power as low as possible and land or bail out as soon as possible.
- The engine's operating limits have been exceeded, or battle damage renders the engine inoperable. This situation may not have a remedy other than an emergency landing or bailing out.

### Engine Failure

Engine failures fall into two main categories: those occurring instantly and those giving ample warning. The instant failure is rare and usually occurs due to battle damage or when ignition or fuel flow completely fails. Most engine failures are gradual and afford the alert pilot some indication that a failure may be approaching. An extremely rough-running engine, loss of oil pressure, excessive coolant temperature under normal flight conditions, loss of manifold pressure, and fluctuating RPM are indications that a failure may occur. When indications point to an engine failure, the pilot should land immediately.

#### Engine Air Restart

The engine cannot be restarted if it fails in flight as the starter is not electrical.

#### Engine Failure in the Takeoff Run

The chances of engine failure during takeoff can be greatly reduced if the engine is run up carefully and checked thoroughly beforehand. If engine failure occurs during the takeoff run before the aircraft leaves the ground, proceed as follows:

- Close throttle completely.
- Apply brakes as necessary to effect a quick stop.
- If doubt exists as to whether the aircraft can be brought to a safe stop on runway, Ignition Selector Switch should be set to "Aus" and the Fuel Feed Selector to "ZU".
- If insufficient runway remains for a safe stop or obstacles cannot be avoided, jettison any external load and raise the landing gear by retracting the safety switch over the Ein (Up) button and pressing the button.
- Roll canopy back or pull the canopy emergency release handle.
- After stopping, get out of the aircraft as soon as possible, and clear the immediate area.

### Engine Failure after Takeoff

If an engine failure occurs soon after takeoff, the pilot has to think fast and take the correct course of action before too much speed is lost and not enough safe ground is available for a landing. Perform the following steps:

- Move the Governor Automation Switch located next to the throttle quadrant to upper (Manual) position.
- Hold the "Drehzahl" thumb button on the throttle quadrant in the "Kleiner" (Fine)
- If failure persists, immediately lower the nose to maintain airspeed.
- Release any external bombs or tanks, if loaded.
- Release the canopy by pulling the Canopy Emergency Release handle.
- If safe landing is in doubt, raise the landing gear.
- If time permits, lower the flaps fully.
- Turn Ignition Selector Switch to "0".
- Move Fuel Tank Selector Lever to "ZU".
- Secure the shoulder harness.
- Land straight ahead.
- After landing, get out and stay out.

### Engine Failure in Flight

If the engine begins to fail during flight, the aircraft may be abandoned, ditched, or brought in for a dead-stick landing. To land with the engine dead, follow these steps:

- Lower the nose immediately so that airspeed does not drop below stall speed. Keep IAS well above stall speed.
- If external tanks or bombs are installed, release them over an uncongested area.
- Move Fuel Tank Selector Lever to ZU.

- Choose an area for landing. If near a landing field, notify the tower. Judge turns carefully and plan to land into the wind.
- Duck your head, lower the seat, and release the sliding canopy by pulling the Canopy Emergency Release Handle.
- If a long runway is available and time and altitude are sufficient to properly plan an approach, raise the landing gear by pressing the AUS button on the right-hand side of the Landing Gear and Flaps Controls. If landing under any other condition, keep the gear up.
- Set wing flaps to START setting, leaving the full AUS setting for compensation of possible mistakes in the final approach. Lower the flaps fully when a safe landing is not in doubt.
- Land into the wind.
- After landing, get out and stay out.

## Fire

In the event of a fire, keep the canopy entirely closed. Opening the canopy will result in the cockpit quickly filling with smoke. Similarly, do not lower the landing gear as this may also blast the fire into the airframe and cause additional damage.

If an engine fire develops, attempt to control the fire by performing the following steps:

- Fuel Tank Selector Lever to "ZU".
- Throttle CLOSED.
- Ignition Selector Switch to "0".

While remaining in the cockpit during a fire, cover all the exposed parts of your body, including your eyes. If the fire situation requires bailing out, only open the canopy when you are ready to leave the aircraft. Don't release the canopy until after you have unlocked the safety harness, trimmed the aircraft, and are crouched with your feet in the seat ready to spring out. Then pull the canopy emergency release handle and lunge upward to the right, pushing the canopy off with head.

## Landing Emergencies

Any situation in which battle damage or system failure makes it impossible to maintain required airspeed in level flight is considered an emergency.

In the event of such an emergency you may attempt to perform an emergency landing, or bail out.

As soon as an emergency occurs, scout the area for potential landing sites and use the following table for information on potential chance of success:

SAFE	Airfield
	Empty field
CAUTION	Meadow
	Sand
	Water surface, calm
	Ice
UNSAFE	Young wood
	Water surface, choppy
	Rough field
	Thick wood
	Hills
	Mountains
	Water surface, storm

When no Safe or Caution landing site is available, emergency landing on Unsafe surface is generally not recommended. You must bail out instead.

### Forced landing on land

- If emergency occurs below 1,000 meters, it is generally recommended to land with the landing gear up.
- If the engine stops suddenly at any time during the emergency landing, immediately point the nose down to compensate for lost airspeed.
- With engine on, maintain 200 to 210 km/h. With engine off, maintain 220 to 230 km/h.
- Determine optimal airspeed based on engine condition, altitude, and distance to selected landing site.
- Try to stick with the selected landing site even if a better opportunity presents itself later.
- Depending on selecting landing site, additional considerations may apply:

- Field or Meadow: If field is cultivated, land parallel to rows of vegetation unless this significantly decreases available landing area. Small bushes and other vegetation do not usually present danger.
- Sand: If wide flat beach is available, landing is nearly as safe as on a runway. Avoid using brakes.
- Ice: Land parallel to the coastline to avoid commonly occurring cracks. Ice near coastline is generally thinner.
- Young wood: Small trees can be ignored and will not usually present danger. Avoid dense groups of small trees.
- Rough field: Ignore ploughing direction and select most advantageous site length.
- Thick wood: landing is generally not recommended. If bail out is impossible, some small chance of success exists. Flare out early and allow thinner tree tops to slow down the aircraft.
- When changing direction with no or limited engine power, increase airspeed to at least 250 km/h for a small turn, and up to 280 km/h for a larger turn.

Please refer to the table below for the range of possibilities.

Altitude	Max direction change	
	Engine On	Engine Off
<b>100 m</b>	15 °	10 °
<b>200 m</b>	45 °	20 °
<b>300 m</b>	70 °	40 °
<b>400 m</b>	100 °	60 °
<b>500 m</b>	140 °	80 °

- Depending on aircraft state and selected landing site, you may choose to jettison or keep the canopy. Jettisoning the canopy may allow you to escape the aircraft quicker to avoid potential explosion; keeping the canopy may protect you from a potential rollover.
- Tighten safety harness.
- Turn the Governor Automation Switch to upper (Manual) position. Set propeller blades to 06:00 (0%) using the Propeller Pitch Rocker Switch.
- If emergency occurs above 1,000 meters, and you have selected a generally safe landing site, you may choose to lower the landing gear.

Once below 1,000 m and 350 km/h, lower landing gear with the Landing Gear Controls. Retracting the safety switch over the Aus (Down) button and press the button. The button remains pressed while the gear is in operation and pops up once the gear is down and locked. The green Aus lights also illuminate on the Landing Gear Position Indicator.

Note: never-exceed airspeed with gear down is 350 km/h.

Ensure the green light illuminates on the Landing Gear Position Indicator.

If the Aus button does not pop up by itself when operation is complete, you must manually pull the button up.

If malfunction occurs during the procedure, you may attempt to press the corresponding button again.

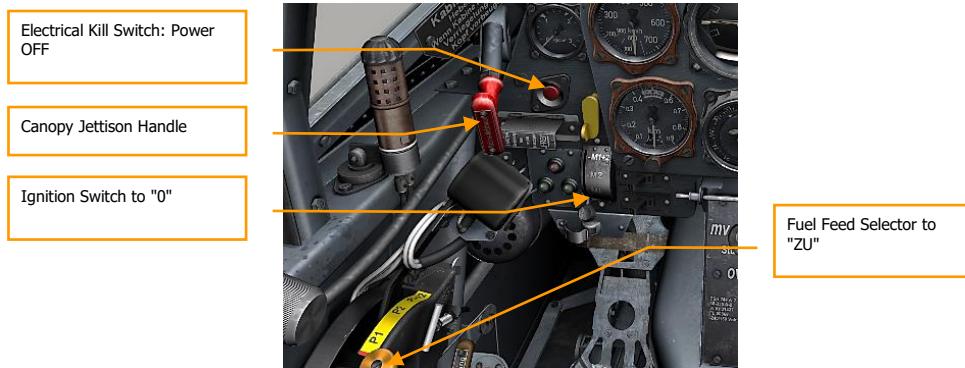
Please note that an audible warning sound will be heard in the cockpit whenever the flaps are down while the landing gear is not in the down and locked position. This is to remind you to lower landing gear on landing, or to notify you that the gear malfunction has occurred.

- Once below 250 km/h and below 1,000 meters, fully lower flaps by using the Flap Control Handwheel.
- Immediately before touch-down, switch Electrical Kill Switch to shut off electrical power.
- Set the Ignition Selector Switch to "0".
- Set Fuel Feed Selector to "ZU".

## Bailing out

If at all possible, decelerate to slowest possible airspeed.

- If there is sufficient time:
  - Use the Electrical Kill Switch to turn all power OFF.
  - Set the Ignition Selector Switch to "0".
  - Set Fuel Feed Selector to "ZU".
- Undo safety harness.
- Jettison the canopy with the Canopy Jettison Handle.



- Begin to jettison the fuel.



- Disconnect the headset and oxygen hose, and release the safety belt and shoulder harness.
- Pull yourself up onto the seat, so that you are in a crouching position with your feet on the seat.
- Dive with head down toward the trailing edge of the right wing, unless a fire or some other condition makes it advisable to go out the left side.
- Alternatively, trim aircraft nose-heavy and push the control stick forward to allow your body to fall up and away from the descending aircraft. Jump out with all available leg power while pushing the stick to attempt to clear the aircraft tail.

## Brake Failure

Remember that the break system is not operated by the hydraulic system of the aircraft and each brake is operated by its own individual pressure cylinder, which is activated by using the brake pedals. It is extremely unlikely, therefore, that both brakes will fail at the same time. When one brake fails, it is almost always possible to use the other in stopping the aircraft.

If one brake goes out while taxiing, use the other (good) brake and also the lockable tail wheel. Immediately chop the throttle and cut the switch. If you're going too fast to stop the aircraft in this matter, lock the good brake, and groundloop until the aircraft stops.

If a brake goes out while checking the magnetos, immediately cut the throttle back and hold the plane in a groundloop with the good brake.

If, when coming in for a landing, you know that your brakes are inoperative – or even if you suspect such a condition – approach the field and land as slow as safety permits. Use full flaps and use your best technique in making a 3-point landing. Stop the engine completely by cutting the mixture control as soon as your plane is on the ground. The dead prop creates additional braking action to help make your landing as short as possible.

If the brakes are locked, never attempt a wheel-type (tail high) landing. If you do, you will either hit the prop or nose over altogether.

## Landing Gear Failure

If the damage or malfunction occurs, remember that you can lower the landing gear by pulling the emergency handle. The procedure is as follows:

- Put the landing control handle in the DOWN position by pressing the "Landung" button.
- Pull the red Landing Gear Manual Release handle. This activates the back-up spring that should release the lock of gear. Rock your wings to bring gear down and lock.

If the back-up mechanism fails to work, no additional options are available.

## Electrical System Failure

The aircraft's electrical system circuits are protected by circuit breakers on the right hand panel.

If a circuit is overloaded, red button will pop slightly out of the panel. To reset, wait a few seconds for the switch to cool, and then give the black button a firm push. If the button pops out again immediately, allow a bit more cooling time and try again. Should repeated effort fail to restore the switch, there's nothing more that can be done to fix it. The circuit is probably shorted and cannot be repaired in flight.

Whenever the generator is shut off, the radio must be used sparingly as it quickly drains the battery.

## Tire Failure

If a tire is low or blown out during a landing approach, perform a 3-point landing. Don't use the brakes until necessary, then use the opposite brake, but only slightly, and enough opposite rudder to keep the aircraft straight.

Land on the left side of the runway if the right tire is flat and on the right side if the left tire is flat.

If a tire is completely lost, do not attempt to land on a rim. Perform a belly landing.

## **Special Landing Conditions**

### **Crosswind Landings**

The recommended procedure for crosswind landing is as follows:

- Maintain airspeeds slightly higher than for a normal approach.
- Drop the wing into the wind slightly to counteract the drift, and keep the plane straight with the runway.
- Just before touching down, level the wings.
- Make a wheel landing if the crosswind is excessive, gusty, strong, or otherwise doubtful. Use approximately half flaps for any appreciable crosswind.

If crabbing is required during the approach, be sure to straighten out before landing. Never land in a crab as it is very stressful on the landing gear.

### **Gusty Landings**

In a gusty wind condition, maintain speeds slightly faster than normal to minimize the likelihood of a sudden loss of lift between wind gusts. Watch for the effect of gust on the aircraft. The gust tends to have a ballooning effect. Then, when the gust quits, the aircraft may drop as lift is reduced, resulting in an impact with the ground.

Use about half flaps when performing a landing in gusty conditions.

### **Wet Landings**

Wet landing require special attention in using the brakes. Avoid jamming the brakes, which could result in skidding out of control. If visibility out of the front wind shield is poor, use the front panels on each side of the windshield.

## Landing Go-Around

Don't hesitate to go around if there is any possibility of a problem occurring while landing. The recommended go-around procedure is as follows:

- Advance the throttle quickly, but smoothly to 2,400 – 2,600 RPM at 1.45 ATA. Avoid a sudden rush of power to prevent a possible loss of control due to increasing torque effects.
- As power is increased, counteract left torque by using right rudder.
- Maintain flap position while climbing to safe altitude.
- Do not exceed 250 km/h with flaps extended.
- Slowly retract flaps. Adjust Horizontal Stabilizer Trim for level flight as needed.
- After your IAS reaches 220 km/h and altitude reaches 300 m, raise the flaps.
- Use the Manual Radiator Flap Control if needed for continued flight.

**Do not make sudden and large throttle movements. Use all of the controls smoothly to avoid a loss of control.**

It's critical to maintain a straight course until enough airspeed is gained to raise the flaps and begin maneuvering.

# COMBAT EMPLOYMENT



# COMBAT EMPLOYMENT

In this section, we will overview weapons employment procedures for the Bf 109 K-4.

## Guns

### Aiming with the REVI 16B Gunsight

The Revi 16B is a standard reflector sight used on many German aircraft. While attempts to introduce lead-computing sights began rather early in the war, the RLM continued to prefer simpler Reflex Sights (Reflexvisier or Revi for short) well into 1944. All reflex sights used by all nations use the same basic principle and project a reticle image onto a sight glass into infinity.

Reflector sights such as the Revi 16B do not compute lead and simply provide a dead aiming point relative to the aircraft gun line.

When using a reflex sight in combat, the pilot has to make manual adjustments to account for target lead, G load, distance to target, and other parameters required for accurate aerial gunnery.

The Revi 16B is equipped with two pilot controls, the Brightness Adjustment Lever and the Sight Dimmer.

The Brightness Adjustment Lever is located on top of the device at the right edge. The lever may need to be adjusted based on current light conditions.

The Sight Dimmer is an additional darker sight glass that can be extended behind the main reticle glass. The Dimmer is used in brightest natural light conditions when the rearmost position of the Brightness Adjustment lever is insufficient to adequately display the reticle.

### Pre-flight Check of the REVI 16B Gunsight

Before takeoff, check the sight as follows:

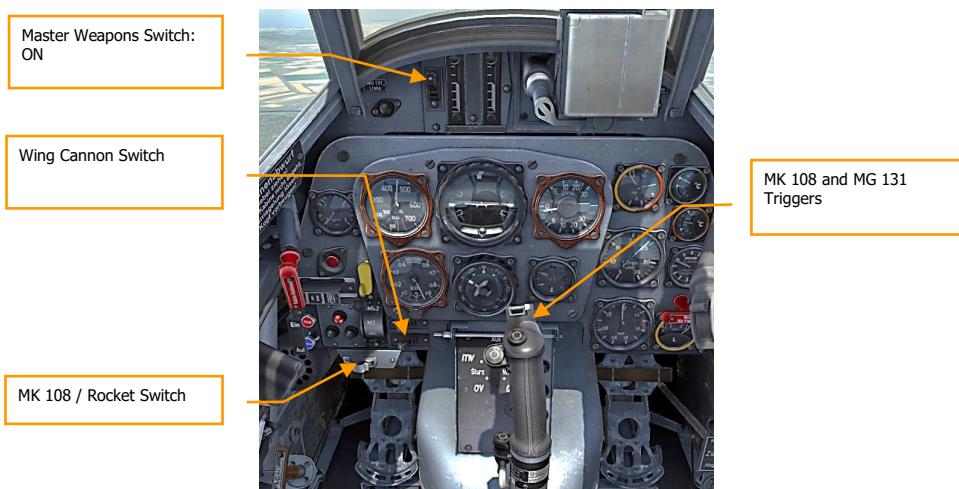
- Rotate sight dimmer rheostat to obtain desired brilliance.
- Pick a point on the horizon; make sure the center of the reticle is aligned with the aircraft centerline.
- Unless anticipating immediate combat, stow the gun sight in the Cruise position by pressing on the sight body and rotating it clockwise.

### Firing Guns with the REVI 16B Gunsight

Normal flight operation of the sight is accomplished as follows:

- If the gun sight is stowed in the Cruise position, move it to the Combat position by pressing on the sight body and rotating it counter-clockwise.
- Enable gunsight lighting with the Revibeleuchtung switch on the Electrical Circuit Panel.
- Enable weapons with the Master Weapons Switch.

- When using rockets and/or underwing gondolas, ensure the MK 108 / Rocket Switch and the Wing Cannon Switch are properly set.
- Identify target.
- Fly the aircraft so that the target appears within the reticle circle.
- Continue to frame the target with the reticle circle. Make course adjustments to account for target lead, G load, and distance to target.
- Track the target smoothly for one second. Then fire.
- As separate triggers are provided, you may choose to fire MK 108 separately or together with the MG 131.
- Continue tracking the target while firing.



## Bombs

### Releasing Bombs

The following is a standard procedure for releasing bombs:

- Determine the desired mission profile.
  - The "Sturz" settings on the left-hand side are used for dive bombing.
  - The "Wagerecht" settings on the right-hand side are used for level bombing.
  - "OV" settings are to be used for bombs dropped from higher altitudes without fuse delay.

- "MV" settings are used for low-altitude bombing with fuse delay to allow the attacker to clear the blast area.
- Set the Bomb Selector Switch to the proper profile and delay position.
- Press the Release Button (B2) on the control stick to release bombs.

Note, bombs may be released when the aircraft is in any pitch attitude from a 30-degree climb to a vertical dive.

**Do not release bombs when you are sideslipping more than 5 degrees in a vertical dive.  
Doing so may collide a bomb and the propeller.**

## Emergency Bomb and Drop Tank Release

The Bombs or the Underfuselage Drop Tank may be jettisoned with the Emergency Fuselage Load Release handle, located on the left side of cockpit wall below throttle quadrant.

## After Combat

Once combat employment is concluded, please perform the following steps:

- Raise the trigger guard to cover the upper trigger.
- Disable weapons with the Master Weapons Switch.
- Stow the gun sight in the Cruise position by pressing on the sight body and rotating it clockwise.

# RADIO COMMUNICATIONS



# RADIO COMMUNICATIONS

There are two optional modes of using the radio that depend on the "EASY COMMUNICATION" OPTION under the GAMEPLAY tab. This setting also determines the key commands used to access the radio menu in-game.

Because the FuG 16ZY radio of the Bf 109 K is limited to 4 channels, you will only be able to communicate with those entities whose frequencies are loaded in your radio. Radio frequencies are loaded in the mission editor by the mission designer and should be made available as part of the mission briefing.

## Easy Communication is enabled

The radio communications window is accessed by a press of the [\\] forward slash key (this is for US keyboards, other language keyboards may vary). After the command selection the radio or interphone will be selected (if required) and tuned (if required) automatically. Also [\\] key will close radio command menu.

When the radio menu is displayed, recipients are color-coded as follows:

Recipients on which at least one of the radios is tuned to is colored white.

Recipients on which at least one of the radios can be tuned to but is not currently on the correct frequency is colored gray.

Recipients that cannot be contacted due to range or terrain masking / earth curvature are colored black.

Each will also have their modulation / frequency listed. When you select a recipient, the appropriate radio will automatically be tuned to communicate with the selected recipient.

When Easy Communications mode enabled, the following 'quick' command shortcuts are also available:

[LWIN + U] Request AWACS vector to home plate.

[LWIN + G] Command flight to attack ground targets.

[LWIN + D] Command flight to attack air defense targets.

[LWIN + W] Command flight to cover me.

[LWIN + E] Command flight to proceed with the mission and return to base.

[LWIN + R] Command flight to proceed with the mission and rejoin.

[LWIN + T] Command flight to open/close the formation.

[LWIN + Y] Command flight to rejoin the formation.

## Easy Communication is not enabled

When Easy Communications mode is OFF, the Push To Transmit (PTT) button [RALT-\] is used to open radio command panel. The PPT button opens and closes the radio communications window for currently selected radio.

When recipients are displayed, there is no color-coding of availability and no listing of their modulation / frequency. This is the more realistic play mode and requires you to know the correct modulation / frequencies for each recipient and you must manually enter the frequencies on the correct radio.

## Radio Communications Window

Top Level Recipient List:

If using "Easy Communications", recipients not present in the mission will not be listed.

**F1. Wingman...**

**F2. Flight...**

**F3. Second Element...**

**F5. ATCs...**

**F8. Ground Crew...**

**F10. Other...**

**F12. Exit**

Hot keys will also be available to directly issue any command in the structure. These can be found in Input Options.

To exit radio communications, you can also press the ESC key.

## F1 Wingman

Upon selecting F1 Wingman from the main radio communications window, you have the option to select the basic type of message you wish to send to your number 2 wingman. These are:

**F1. Navigation...**

**F2. Engage...**

**F3. Engage with...**

**F4. Maneuvers...**

**F5. Rejoin Formation**

**F11. Previous Menu**

**F12. Exit**

## F1 Navigation...

The Navigation options allow you to direct where your wingman will fly to.

**F1 Anchor Here.** Your wingman will orbit at its current location until you issue a Rejoin command.

**F2 Return to base.** Your wingman will return to and land at the airbase designated in the flight plan.

**F11 Previous Menu**

**F12 Exit**

## F2 Engage...

The Engage options allow you to direct your wingman to attack a specific type of target. After issuing the order, the wingman will attempt to locate the specified target type and attack it.

**F1 Engage Ground Target.** Wingman will attack any enemy ground unit it can locate.

**F2 Engage Armor.** Wingman will attack any tanks, infantry fighting vehicles, and armored personnel carriers it can locate.

**F3 Engage Artillery.** Wingman will attack any tube artillery or multiple rocket launchers that it can locate.

**F4 Engage Air Defenses.** Wingman will attack any enemy anti-aircraft artillery and surface to air missile units that it can locate.

**F5 Engage Utility Vehicles.** Wingman will attack all supply, transport, fuel, power generation, command and control, and engineering units it can locate.

**F6 Engage Infantry.** Wingman will attack hostile infantry units. Note that the infantry units are very difficult to detect unless they are moving or firing weapons.

**F7 Engage Ships.** Wingman will engage enemy surface combatants. Note that most surface combatants are heavily armed and that the Bf 109K is not well-suited to attacking such targets.

**F8 Engage Bandits.** Wingman will engage any enemy fixed-wing and rotary-wing aircraft it can locate.

**F11 Previous Menu**

**F12 Exit**

## F3 Engage With...

Whereas the F2 Engage command allows you to give basic orders for your wingman to attack a target type, the F3 Engage With set of commands not only allows you to determine target type, but also the direction of attack and what weapon type to use. This is done in a tiered manner by first selecting target type, then weapon type, and finally the attack heading. The wingman will then attempt to locate targets of the specified type and attack them according to your specified weapon and attacking heading. While the F2 Engage options are fast to issue, the F3 Engage With options provides much greater control.

**Target Type.** These options mirror those of the F2 Engage orders and allow you to determine the type of ground target you want your wingman to engage.

**F1 Engage Ground Target.** Wingman will attack any enemy ground unit it can locate.

**F2 Engage Armor.** Wingman will attack any tanks, infantry fighting vehicles, and armored personnel carriers it can locate.

**F3 Engage Artillery.** Wingman will attack any tube artillery or multiple rocket launchers that it can locate.

**F4 Engage Air Defenses.** Wingman will attack enemy anti-aircraft artillery and surface to air missile units that it can locate.

**F5 Engage Utility Vehicles.** Wingman will attack all supply, transport, fuel, power generation, command and control, and engineering units it can locate.

**F6 Engage Infantry.** Wingman will attack hostile infantry units. Note that the infantry units are very difficult to detect unless they are moving or firing weapons.

**F7 Engage Ships.** Wingman will engage enemy surface combatants.

**Weapon Type.** Once you have selected the target type, you will be given a list of weapon types that you want your wingman to engage the target with. These include:

F2 Unguided Bomb...

F4 Rocket...

F6 Gun...

**Attack Heading.** After you've selected the weapon type for your wingman to use, the third and final step is to determine the attack heading that you wish your wingman to use. This can be useful to help it avoid overflying enemy defenses. The options include:

**F1 Default.** Wingman will use the most direct heading to attack the target.

**F2 North.** Wingman will attack the target from south to north.

**F3 South.** Wingman will attack the target from north to south.

**F4 East.** Wingman will attack the target from west to east.

**F5 West.** Wingman will attack the target from east to west.

## F4 Maneuvers...

Although your wingman will generally do a good job of knowing when and how to maneuver, there may be times when you want to give him/her a very specific maneuvering order. This could be in response to a threat or to better set up an attack.

**F1 Break Right.** This command will order your wingman to make a maximum-G break to the right.

**F2 Break Left.** This command will order your wingman to make a maximum-G break to the left.

**F3 Break High.** This command will order your wingman to make a maximum-G break high.

**F4 Break Low.** This command will order your wingman to make a maximum-G break low.

**F7 Clear Right.** Your wingman will perform a 360-degree turn to the right of the current flight path while searching for targets.

**F8 Clear Left.** Your wingman will perform a 360-degree turn to the left of the current flight path while searching for targets.

**F9 Pump.** Your wingman will perform a 180-degree turn from its current heading and fly 10 nm. Once reached, it will turn 180-degrees back to the original heading.

## F5 Rejoin Formation

Issuing this command will instruct your wingman to cease its current task and rejoin formation with you.

## F2 Flight

Upon selecting F2 Flight from the main radio communications window, you have the option to select the basic type of message you wish to send. These are:

**F1 Navigation...**

**F2 Engage...**

**F3 Engage with...**

**F4 Maneuvers...**

**F5 Formation**

**F6 Rejoin Formation**

**F11 Previous Menu**

**F12 Exit**

### F1 Navigation...

The Navigation options allow you to direct your flight where to fly to.

**F1 Anchor Here**

**F2 Return to base**

**F11 Previous Menu**

**F12 Exit**

**These commands mirror those of the Wingman Navigation commands but apply to all flight members.**

## F2 Engage...

The Engage options allow you to direct your flight to attack a specific type of target. After issuing the order, the flight will attempt to locate the specified target type and attack it.

**F1 Engage Ground Target**

**F2 Engage Armor**

**F3 Engage Artillery**

**F4 Engage Air Defenses**

**F5 Engage Utility Vehicles**

**F6 Engage Infantry**

**F7 Engage Ships**

**F8 Engage Bandits**

**F11 Previous Menu**

**F12 Exit**

**These commands mirror those of the Wingman Engage commands but apply to all flight members.**

## F3 Engage With...

These commands mirror those of the Wingman Engage With commands but apply to all flight members. These commands work the same as the Wingman Engage With Commands described above.

## F4 Maneuvers...

**F1 Break Right**

**F2 Break Left**

**F3 Break High**

**F4 Break Low**

**F7 Clear Right**

**F8 Clear Left**

**F9 Pump**

**F11 Previous Menu**

**F12 Exit**

These commands mirror those of the Wingman Maneuvers commands but apply to all flight members.

## F5 Formation

From the Formation menu, you can select the formation that the flight will fly in relation to you as the flight leader.

**F1 Go Line Abreast**

**F2 Go Trail**

**F3 Go Wedge**

**F4 Go Echelon Right**

**F5 Go Echelon Left**

**F6 Go Finger Four**

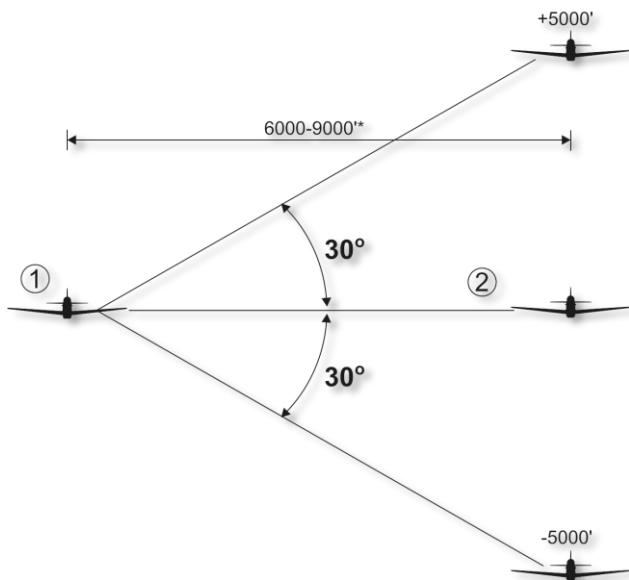
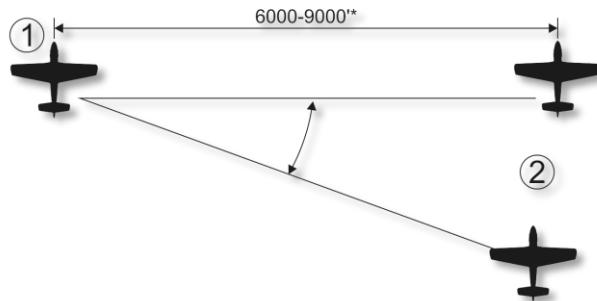
**F7 Go Spread Four**

**F8 Open Formation**

**F9 Close Formation**

**F11 Previous Menu**

**F12 Exit**



**Figure 99: F1 Go Line Abreast**



**Figure 100: F2 Go Trail**

Position may be modified within a 4000-12,000' envelope by flight lead.

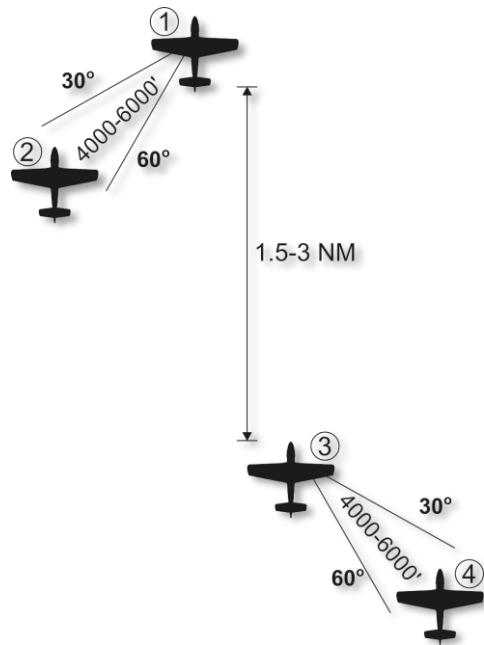


Figure 101: F3 Go Wedge

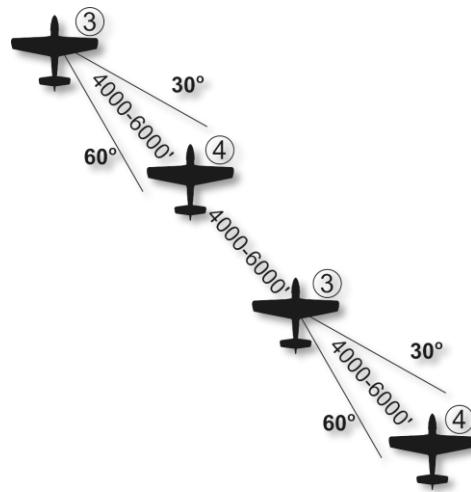


Figure 102: F4 Go Echelon Right

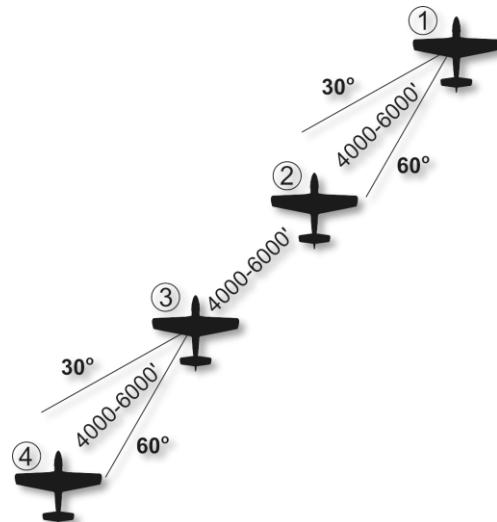
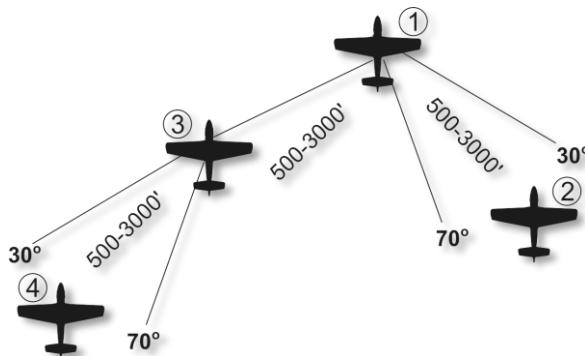


Figure 103: F5 Go Echelon Left

**Figure 104: F6 Go Finger Four**

Position may be modified within a 4000-12,000' envelope by flight lead.

**Figure 105: F7 Go Spread Four**

Position may be modified within a 4000-12,000' envelope by flight lead.

**F8. Open Formation.** Increase the distance between each aircraft in the current formation.

**F9. Close Formation.** Decrease the distance between each aircraft in the current formation.

## F6 Rejoin Formation

Issuing this command will instruct your flight to cease their current task and rejoin formation with you.

## F3 Second Element

Upon selecting F3 Second Element from the main radio communications window, you have the option to select the basic type of message you wish to send to the second element of your flight. The second element consists of flight members 3 and 4 with number 3 being the element lead. When issuing a command to Second Element, number 3 and 4 carry out the order jointly. These commands are:

- F1 Navigation...**
- F2 Engage...**
- F3 Engage with...**
- F4 Maneuvers...**
- F5 Rejoin Formation**
- F6 Out**
- F11 Previous Menu**
- F12 Exit**

## **F1 Navigation...**

The Navigation options allow you to direct your second element where to fly to.

- F1 Anchor Here**
- F2 Return to base**
- F11 Previous Menu**
- F12 Exit**

**These commands mirror those of the Wingman Navigation commands but apply to the second element.**

## **F2 Engage...**

The Engage options allow you to direct your second element to attack a specific type of target. After issuing the order, the wingman will attempt to locate the specified target type and attack it.

- F1 Engage Ground Target**
- F2 Engage Armor**
- F3 Engage Artillery**
- F4 Engage Air Defenses**
- F5 Engage Utility Vehicles**
- F6 Engage Infantry**
- F7 Engage Ships**
- F8 Engage Bandits**
- F11 Previous Menu**
- F12 Exit**

**These commands mirror those of the Wingman Maneuvers commands but apply to the second element.**

## F3 Engage with...

These commands mirror those of the Wingman Maneuvers commands but apply to the second element.

## F4 Maneuvers...

Although your second element will generally do a good job of knowing when and how to maneuver, there may be times when you want to give him/her a very specific maneuvering order. This could be in response to a threat like an incoming SAM, or to better set up an attack.

**F1 Break Right**

**F2 Break Left**

**F3 Break High**

**F4 Break Low**

**F7 Clear Right**

**F8 Clear Left**

**F9 Pump**

**F11 Previous Menu**

**F12 Exit**

These commands mirror those of the Wingman Maneuvers commands but apply to the second element.

## F5 Rejoin Formation

Issuing this command will instruct your second element to cease its current task and rejoin formation with you.

# Flight Member Responses

After sending a radio message to any of your flight members, you will have one of two responses:

**Flight number of responder (2, 3, or 4).** When a flight member will carry out the order, it will respond simply with its flight number.

**(Flight member number) unable.** When a flight member cannot carry out the order, it will respond with its flight number following by "unable". For example: "2, unable"

## F5 ATC

The Air Traffic Control (ATC) system of this simulation is context sensitive to the location of your aircraft: on the parking ramp or runway/airborne.

Because the FuG 16ZY radio of the Bf 109 K-4 is limited to 4 channels, you will only be able to communicate with those entities whose frequencies are loaded in your radio. Radio frequencies are loaded in the mission editor by the mission designer and should be made available as part of the mission briefing.

Each airdrome's tower has a several radios in different radio bands to have a radio communication with aircrafts of different types.

ATC Communication Frequencies for Bf 109 K-4 radio band:

Anapa-Vityazevo: 38.40 MHz

Batumi: 40.40 MHz

Gelendzhik: 39.40 MHz

Gudauta: 40.20 MHz

Kobuleti: 40.80 MHz

Kutaisi (Kopitnari): 41.0 MHz

Krasnodar Center: 38.60 MHz

Krasnodar-Pashkovsky: 39.80 MHz

Krymsk: 39.0 MHz

Maykop-Khanskaya: 39.20 MHz

Mineralnye Vody: 41.20 MHz

Mozdok: 41.60 MHz

Nalchik: 41.40 MHz

Novorossiysk: 38.80 MHz

Senaki-Kolkhi: 40.60 MHz

Sochi-Adler: 39.60 MHz

Soganlug: 42.0 MHz

Sukhumi-Babushara: 40.0 MHz

Tbilisi-Lochini: 41.80 MHz

Vaziani: 42.20 MHz

Beslan: 42.40 MHz

**Parking Ramp Start**

Before you can communicate with ATC/Ground Control to get permission to start your engine, you first need to have your VHF AM radio up and running.

With the radio now operating, press [\] or [RALT +\] to bring up the radio menu and then press F1 "Request Engine Start".

If you have wingmen, they will also now start their engine.

After the aircraft has been started and configured, select F1 "Request taxi to runway". Once you receive permission, you can taxi to the "hold short" area of the taxiway - the area on the taxiway just short of entering the runway.

If you have wingmen, they will also now taxi to the runway.

When at the hold short area, press [\] or [RALT +\] and F1 "Request takeoff". When permission is granted, you can taxi on to the runway and takeoff.

**Runway and Air Start**

If you are not starting from the parking ramp, you can access ATC by pressing the [\] or [RALT +\] key. Upon doing so, you can select F5 "ATCs".

If you are using "Easy Communications", a list of airfield ATCs are listed along with their contact frequencies. Select the airfield ATC you wish to contact. If not using Easy Communications, you will first need to push channel button of assigned ATC frequency you wish to land on the radio.

Once the airfield ATC is selected, you can either send them an "Inbound" message to indicate that you intend to land there, or an "I'm lost" message that will result in the ATC providing you guidance to reach the airfield.

When you select "Inbound", the ATC will respond with the following information:

Heading to fly to reach landing initial point.

Range to landing initial point.

The QFE, or atmospheric pressure at the airfield elevation.

Which runway to land on.

You can then radio:

"Request landing" indicates your intent to land at directed runway.

"Abort landing" indicates that you will not be landing at the directed runway.

"I'm lost" requests navigation assistance to reach the airfield.

If you've requested landing and are on final approach, radio request landing a second time and ATC tower control will provide permission if the runway is clear. It will also provide wind direction and speed.

After you have landed, proceed to the parking area and shut down the aircraft.

## F6 Ground Crew

After landing at a friendly airfield and taxiing to a parking ramp, you can communicate with the ground crew for re-arming and re-fueling by pressing the F6 option to display the Ground Crew menu.

# SUPPLEMENTS



# SUPPLEMENTS

## Airdromes Data of Caucasus Map

Airdrome	Runway	TACAN, channel	ILS	RSBN channels		Outer NDB, kHz	Inner NDB, kHz	Tower comm frequencies, MHz
				N	P			
UG23 Gudauta - Bambora (Abkhazia)	15-33, 2500m					395 (33)		209.00/130.0/40.20 /4.20
UG24 Tbilisi - Soganlug (Georgia)	14-32, 2400m							218.0/139.0/42.0/4 .65
UG27 Vaziani (Georgia)	14-32, 2500m	22X (VAS)	108.75					219.0/140.0/42.20/ 4.70
UG5X Kobuleti (Georgia)	07-25, 2400m	67X (KBL)	07 ILS - 111.5			870	490	212.0/133.0/40.80/ 4.35
UGKO Kutaisi - Kopitnari (Georgia)	08-26, 2500m	44X (KTS)	08 ILS - 109.75				477 (08)	213.0/134.0/41.0/4 .40
UGKS Senaki - Kolkhi (Georgia)	09-27, 2400m	31X (TSK)	09 ILS - 108.9			335 (09)	688 (09)	211.0/132.0/40.60/ 4.30
UGSB Batumi (Georgia)	13-31, 2400m	16X (BTM)	13 ILS - 110.3				430 (31)	210.0/131.0/40.40/ 4.25
UGSS Sukhumi - Babushara (Abkhazia)	12-30, 2500m					489	995	208.0/129.0/40.0/4 .15
UGTB Tbilisi - Lochini (Georgia)	13-31, 3000m		13 ILS - 110.3 31 ILS - 108.9			342 (13) 211 (31)	923 (13) 435 (31)	217.0/138.0/41.80/ 4.60
URKA Anapa - Vityazevo (Russia)	04-22, 2900m					443	215	200.0/121.0/38.40/ 3.75
URKG Gelendzhik (Russia)	04-22, 1800m						1000	205.0/126.0/39.40/ 4.00
URKH Maykop - Khanskaya (Russia)	04-22, 3200m			34	36 (04)	288	591	204.0/125.0/39.20/ 3.95
URKI Krasnodar - Center (Russia)	09-27, 2500m			40	38 (09)	625	303	201.0/122.0/38.60/ 3.80
URKK Krasnodar - Pashkovsky (Russia)	05-23, 3100m					493	240	207.0/128.0/39.80/ 4.10
URKN Novorossiysk (Russia)	04-22, 1780m							202.0/123.0/38.80/ 3.85
URKW Krymsk (Russia)	04-22, 2600m			28	26	408	803	203.0/124.0/39.0/3 .90
URMM Mineralnye Vody (Russia)	12-30, 3900m		12 ILS - 111.7 30 ILS -			583	283	214.0/135.0/41.20/ 4.45

		109.3					
URMN Nalchik (Russia)	06-24, 2300m	24 ILS - 110.5			718 (24)	350 (24)	215.0/136.0/41.40/ 4.50
URMO Beslan (Russia)	10-28, 3000m	10 ILS - 110.5			1050 (10)	250 (10)	220.0/141.0/42.40/ 4.75
URSS Sochi - Adler (Russia)	06-24, 3100m	06 ILS - 111.1				761 (06)	206.0/127.0/39.60/ 4.05
XRMF Mozdok (Russia)	08-27, 3100m		20	22	525	1065	216.0/137.0/41.60/ 4.55

## Airdromes Data of NTTR Map

Airdrome	Runway	TACAN, channel	ILS	Tower comm frequencies, MHz
KXTA Groom Lake AFB (USA)	14L-32R 3500m	18X (GRL)	32 ILS - 109.30 (GLRI)	252.0/123.0/38.8
KINS Creech AFB (USA)	13-31 1500m, 08-27 2700m	87X (INS)	13 ILS - 108.5 (ICRS)	251.0/122.0/38.6
KLSV Nellis AFB (USA)	03L-21R 3000m, 03R-21L 3000m	12X (LSV)		254.0/125.0/39.2
KLAS McCarran International (USA)	07R-25L 3100m, 07L-25R 3300m, 01R-19L 2500m, 01L-19R 2500m	116X (LAS)	25 ILS - 111.75 (IRLE)	253.0/124.0/39.0

# Eagle Dynamics

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Oleg "Olgerd" Tischenko	Avionics
Vladimir Feofanov	AI AC flight dynamics
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Eugeney Panov	AI
Michael Ershov	AI

---

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## Land Warfare Department

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Eugeniy "GK" Khizhnyak	AC, vehicles
Constantine Kuznetsov	Sound engineer
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Yury Starov	AC models
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Oleg "Dzen" Fedorenko	Testing

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Konstantin "MotorEAST" Kharin	Customer support
Alena Yurykovskaya	Customer support

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CHSubZero  
Golani79  
Jponti

JST

KIZIR\_77

Ovenmit

Reflected

Snowsniper

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Matthias "Groove" Techmanski

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Werner "derelor" Siedenburg

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Mikael Harju	James dietz	UsF
Kevin Witt	siva	taratuta
Markus Berella	Andy McIntyre	Tommy Tomaszewski
Bodhi Stone	Jordi Haro	subject to change
Toni Wasama	Thomas Guiry (tf_t4trouble)	Vladimir Škorić
Bob Petrone	Kevin M. (tf_Stryker)	philux
Tim Hawkins	Larry Jones	Rune Hasvold
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=DRACO=	graylobo	Timo Vestama
sfer314	kenneth	Matt Styles
Richard Hickerson	Ben Jarashow	Paul Miller
Rico Reyes	Aki Holopainen	David Rilstone
Jeff Zhou	Magnus Andersson	David Miles
Joseph Piasecki	Randy Erwin	Kim Fast
KS	ivdadrelbul	Martin Støy
Michael Landshman	Sergey Mozheyko	Michael Walker
ROSS_Borman	Dalminar	Mattia Garuti
Jack Wilson	Michael Petrarca	Mark Shepheard
Craig	Matt Renfro	Trevor Tice
Thomas Lipscomb	Dan Antonescu	Martin Ponce
Wayne Dickinson	Andreas Pichler	Adrian Cretu
Jared Macon	Mick Alden	Giovanni Degani
Darryl Chupp	Ilia	Sean Tudor
James Nielsen	Brian Lanham	WhiskeyBravo
Tobias A	Denis Winters	Michael Lajeunesse
Alexander Vasilyev	jameson	Chris Madera
Jared Fast	David Gregory	Dmitry Khonin
The Shoveler	Antonio Manuel Ortiz Seguel	Franciscus Berben
Hrvoje Topličanec	Thomas Harkless	Bo Henriksen
k05	Jeff Dodson	Martin Moráček
Roland Schulpen	hangar16	wuffman
Azametric		

Ian Bishop	Juan Soler Huete	Andy Toropkin
M. Zychon	Robert Haynes	Joonas Savolainen
ANV	David Southall	Matthew Kozachek
JeepRazdor	weisse13	David Egerstad
Viacheslav	ROGIER	Deascii
Conrad Lawrence	ugo cozza	Michael Ditter
David Ordóñez	PH	shurke
Jim Allison	Alexander Orevkov	Bochkarev Leonid
kcstokes	Wienerschnitzel	James D Brown
Christopher Scarre	TerminalSaint	Aaron Pratt
Andrey ScorpYX	Derinahon	Tom Summers
Vadim Adel	Pablo M Derqui	Miguel Angel González Domingo
Hasse Karlsson	Steve Chatterton	Aapef
Gary F. Tinschert	David Tydeman	Matthijs
Gary Edwards	Daniel Holst	Michael Miles
Josh lee	Jochen Hamann	Zinoviy Khutoryan
Alex6511	gary doiron	Paul Tricker
Helldiver	David DuBois	Tomasz Szulc
Danny Vanvelthoven	Robin Harroun	Gabor Buzasi
Emilio Londono	Kev	Michiel Jongenelen
Angustimus	Sideris Fotis	Nicklas Sjöqvist
Jeffrey Gumbleton	Konstantin Dibrov	Kimmo Eklund
Bill	Peter Baltzer Hansen	Bertrand Heurtefeu
Troy Nakauchi	Alex	Brian Lee Faull
Jaron Taylor	Peter Wiklöf	Ilja Osovin
Steve Cook	Bogart Hall	Josh McLloyd
Kenneth Knudsen	Steven Myall	robert peterson
Angus MacQueen	DAVID R COLEY	Robert Noke
Ramsay Beshir	Charles Jesch	Don Menary
MarkHawk	cv	Patman DM
Miguel Arias	Gary Lisney	

Paul Dyer	Carl Meyers	Victor99
Adam Jasiewicz	Robert Zuk	Matthew Fortino
Antti Kalliomäki	Aleksei Ivanov	Gabe Garcia
Juergen Dorn	Niklas Nordgren	Jacob Ellis
Simon Aplin	apollo01	Jarred Nation
Göran Wikman	Anton Ottavi	Jip sloop
Kristian Wall	Richard Mater	Mahler
Mikal Shaikh	saif ghadhban	Mark Tredna
Saad Eldeen Bahloul	Michael Rezendes	Logan Lind
antonio dasilva	Yuke kaito	karl bullard
Felix Mueller	Siv	Broodwich
Christopher D. Chambers	Matjaž Mirt	Aleksandr Kochelaev
Jason	Ching-Ling Hsu	Edwin Szekely
Alan Wade	PbICb	Eee3
Jason Michl	Giedrius Balynas	Ivan Kolincak
Cory Parks	Joshua Kozodoy	Per-Erik Linden
Markus Wohlgemann	Mauro Arguelles	Magnus Innvær
jaosn	Kenneth Wong	Michael Rochon
donald dewulf	Robert Roberge	Alan_Grey
Thomas Berg	Max Michaelis	Nicolae Soanea
Patrick Barnhill	Jan-Erik Saxevell	Alfredo Laredo
David Setchell	FFalcon	jim alfredsen`
Henric Ceder	Robert M	Shawn Vowell
Zachary Layne	Fredrik Sjöborg	Scott Eckrich
Terry Scott	Matthew Schneider	Vasco Charles Morais-Boulay
Tyler Krebs	Andrey Dvornik	Petter Lausund
TerribleOne	Sergey Nikishin	Ben Birch
Dakpilot	Eric Dickerson	Pete Jockel
Pablo Alvarez Doval	Maxim Gromada	Rick Dodge
Jacob Williams	Daniil	william neil harding
Mark Linnemann	ALFA_49	

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Ian Persson	Daniel Gestl	Scott Withycombe
James Stephen	Marc-David Fuchs	Capgun
Terry	Jose Manuel	Thomas Cofield
Aram		Alexey Ibragimov
Jefferson Santos	<b>Silver Backers</b>	
RvGils		Daniel Vukmanich
Michael Sprauve	Rayvonn Core	Nicholas Landolfi
Jan Ctrnacty	enrique colome	Arrie
Gene Bivol	TrailBlazer	Mathew Crane
Julian Gaffney	pavlich	Tom Tyrell
Charmande	Lawry Playle	Evan Kosnik
Mehth	Michael G Ribordy	John Hannan
John Huff	modernatomic	Tim Chapman
NATALYA DOLZHENKO	Iain Colledge	jim crimmins
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David Whitehead		Olaf Walter

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Stefan Bohn	Vaclav Danek	Sorin Secu
andrew norgrove	Lanzalaco Salvatore	Joe Dionisio
Tibor Kopca	Janusz	Warmoer
Mario von Thenen	Knut Hanssen	Johan Törnhult
Pedro Mellado	Ljas	Mark Siminowski
Andrew Payne	Thomas Falmbigl	James Sterrett
Graham Smart	Michael Heron	Michael C Ringler
Aviad Tobaly	Ville Ilkka	Ryan Denton
Tyler Moore	David O'Reilly	James F Miller
Allan Spears	Stephen Morrison	Dalton Miner
Jens Kadenbach	Royraiden	James Cook
Dave Kelly	Torsten Tramm	Mike O'Sullivan
Nick	Ken Biega	Andres Riaguas
Ian Seckington	Andrew Brown	Antonio Ruotolo
James Cross	David Levy	Joseph Krueger
Mikko Laukkonen	Karsten Borchers	Chris Payne
Fangqiu Zhu	Jerry Frost	Carl Lyles
Austin Moses	Michal BIZON	Korotky Vadim
Richard Harris	James Phelan	Kenneth Avner
Kevin Garrett	Kiefer Jones	Mason Flake
Gregory Foran	Sigurd Hansen	Ryan Yamada
Penpen	Jorin Sheaffer	oat03001
Prvt.SNAFU	Robert Ian Charles Fellows	g_nom21
Mark Watson	Måns Gotare	davisballen
DarKcyde	Ashley Ellis	ian leslie finlay
Keith Young	Wade Chafe	Kaijев
Scruffy	Jonathan Lim	PakoAry
Mark Delahay	Eduardo Gutiérrez García	Evert Van Limbergen

Jeff Kerian	ApeOfTheYear	Paul Cucinotta
Christoph Jaeger	Famin Viacheslav	Robert Conley III
Devin Ragsdale	Vit Zenisek	Sean Walsh
José Oltra Martínez	William Pellett	Trevor Tranchina
Steve Harmer	Victor Nakonechny	Thomas Fuchs
David McCallum	Nurbol	George Neil
Sebastien Clusiau	Tobias Kiedaisch	Kyle Colyer
Jordan Marlivate	Sam Carlson	W. Duncan Fraser
Michael Riley	John Nespeco	Joe Veazey
Stefan V	DJB	San Mecit Erdonmez
JST	Jakob Boedenauer	tough boy
Bas Weijers	Glen Murphy	Ian Buckler
Jonathan Clarke	Tempered	Jamie Denton
Matti Lund	DDB	Marek Ratusznik
Roman Frozza	Jacob Eiting	gerard o'dwyer
sdpg_spad	Joshua Blanchard	Chris Osterhues
lemercier cedric	James L. Rumizen	Yukikaze
Arcady Chernavin	Mdep5809	Ishtmail
Duncan Hewitt	Dr. Stefan Petersen	Mark McRae
Jim Valentine	DanMe	Bruce Wilson
Ye91	Bruce Mackay	Axion
Wasserfall	Nick Iassogna	Alexandre Tellier Talbot
Marcelo Tocci Moreira	Tim Collins	MK
Youngmok Rhyim	Scott Heimmer	Chance
Hassel Krauss	Drew Pedrick	Alain Becam
Matthew Walker	Christopher Nee	Roman Kolesnikov
Aleksey Kopysov	Viktor Baksai	Jake O'Mahony
ivan decker	Brad Ernst	Oliver Sommer
Juliano Simoes Haas	Glenn Pechacek	Forest Faltus-Clark
Daniel Agorander	Stephen M Zarvis	War4U
Nick Mowbray	John Vargas	Angel Morata

Fredrik Petersson	Arto Santasalo	Ross White
Totoaero	Lunovus	Martin Scholz
garengarch	Steve Gentile	Micha Tanny - a.k.a IAF_Phantom
Jeroen Gommans	Robert Cannon	Bjarne Stig Jensen
paul green	Colin	Colin Rowland
Shannon Craig	Jeffrey A Bannister	Craig Gillies
Sergey Ravicovich	Jeffrey Walsh	Jez Brown
chardon	Brett Bodie	Massimiliano bonin
Tim Mitchell	Bearcat	Runefox
Bjoern Wiederhold	Jason Brown	Ian Keenan
Adrian Havard	Stephen Hulme	Dan Randall
Christoph N	Sheldon cannon	Michael Illas
Stefan Jansen	Daniel Dillman	Otto Conde de Resende
sdo	Nicolas Belanger	Robert Holleman
robert kelly	Alanthegreat	Jukka Huhtiniemi
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Aaron Zmarzlinski	Mike Todd	Ori Pugatzky
Remco	ryan brantly	michael
Nick Vamis	Vit Premyslovsky	Benjamin Frost
Frerk Schmidt	Scott Beardmore	Crimson Machete
David Weaver	Ray West	Hansang Bae
Sergey Velikanov	Iran Fernandes de Oliveira	Eric Staton
Sherif Hosny	David Craig	Wang Feng
Nils Thiel	Jason Reynolds	Rob Brindley
Tim Wopereis	Anthony Chant	Thomas Ruck
Torsten Tramm	Jinder Greewal	Brian Scott Pagel
Jeroen Wedda	Conrad Smith	Insy
Adam Murray	Andrew Fudge	

kevman	Patrick O'Reilly	AKUser99
Reinhard Eichler	Mark Gaffney	Matthew Enloe
Leif Lind	jeremy	Sega Dreamcast
ATAG_Old_Canuck	Cian Quigley	Jean-Pierre Weber
Robert Bähr	Paul Adcock	Peter Scaminaci
Iker ulloa	Greg Huffman	Yaniv Harel
RF	Tom Bies	Eric Keith Robinson
Peter Bartlam	Tim Morgan	David Horkoff
Jasper Hallis	Igor K.	Craig Brierley
Jordan Forrest	kurnz	Kenneth Sapp Jr.
fedja	Benjamin de Rohan	Jack Gurley
Jonathon Kinnin	Sébastien Vincent	Titus Ou
Rey	Roy Woodworth	Ron Cassinelli
Berkes Attila	Nick Maurette	Kestutis Zilys
hansen	Michael Benton	Gary N. Peden
Scott Gorring	Qi Huo	Joe Troiber
Sebastian Riebl	jamie	Brian Kanen
Axel Haake	Blake Cetnar	Ron Brewster
Martin Winter	Drum_Tastic	Alexey Slavutskiy
greco bernardi	Douglas Watson	Michael Smith
Elfin	Zappatime	Hammed Malik
Martin Gronwald	Matt Engelhart	Eric Koepp
oldracoon	Edward Kiervin	Timothy J. Burton
William Skinner	dennis worley	Dennis Camosy
Johan Soderholm	Michael Rishel	John Lynn
Khaydanov Yuriy	Scott Fligum	Tien Brian
Boomerang	Mark A. Kirkeby	Colin McGinley
Alex "Razorblade"	Tom McGurk	Gerald Gong
Alexander Casanova	Paul Hughes	Ryan Thomas Jaeger
Jared Sorensen	Charlie Orchard	Jason Deming
Adam	Edward Winsa	William S. Ball

Eponsky_bot	Daniel Erlemeyer	Rick Zhang
Ronald Hunt	Kent-Ruben Elvestrand	Jiong Zhang
Michael Jochim	brimen	Gary
Arthur Changry	Heinz-Joerg Puhlmann	Allan Taylor
Jamees Hancock	jcenzano	Bennett Ring
Richard Stinchcomb	roman	Bastiaan Jansen
Charles Savas	Jason Montleon	Libor Stejskal
Chris H	Falco	David Maclean
Wayne Berge	Marco Landgraf	Sokolov Andrey
Wes Murks	tkmr	Chris Schultz
Russ Beye	Brandt Ryan	Zaxth - Weresheep of Sin
Juris L Purins	Andrew Spanke	desert eagle540
mike richgruber	Matt Lind	Paul Walker
kurt Weidner	Bryan Baldigowski	Mitchell Sahl
Karfai Michael Yau	Chris Cantrell	Cornay Sinac
Geoffery Jensen	Daniel Marsh	Markus Sohlenkamp
Thomas Dye	Benjamin Freidin	Stanislav Sereda
Robert Schroeder	Chris C	Paul Elton
Leon Higley	SimFreak	Hans-Joachim Marseille
Tobalt	Manuel Ramsaier	Rae
Braden Johel	Olivier Anstett	Nyary Laszlo-Carlo
Seeker37	Tor Stokka	Conny Näslund
Polar	Kirk Lange	Kevin Clarke
Alex Pekarovsky	Timo Wallenius	Vaz
airdoc	Christoph Jungmann	Erich Kreiner
Barry Maunsell	David Penney	Axel Miedlig
Peter Reinhard	alfonso cordoba aguilera	Jörgen Toll
Maler	Flagrum	Euan Arthur Emblin
Todd Bergquist	Edin Kulelja	Jose Luis Navarro Reus
James Schlichting	Iván Pérez de Anta	Graham Wilson
Peter Krause	Col Shaw	Ian Kaiser

Peter Stephenson	Jon Isaacs	Dave Reichard
Christian Gomolka	Eldur	
Michael Umland	Feldmann	
Lawrence Lester	Matthew Horrigan	<b>Gold Backers</b>
Dave Farr	Doug Elliott	
Hannu Heino	Espen Hundvin	Phantom88
Neil Merrett	Mark Clark	Or Yaron
Christopher Ludgate	Einar Oftebro	Måns Serneke
Markus	Danny Stevenson	Polaris Penguin
Mark Thorp	pedro	Marius Backer
Darrell Herbert	Cory Avery	Peter Fritz
Alfredo Croci	Shaun Cameron	Joan Sabater
Tyler Gladman	Iffn	Jim Van Hoogevest
Julian Urquiza	Ante Turkovic	Sergey Ipolitov
John Regan	Ashley Bennett	Joseph Anthony Elliott
Joel Opdendries	George Bonner	Tony Webber
Stewart Forgie	Greg Appleyard	LP
Vendigo	Anton Quiring	Akshay Tumber
Sean Buchanan	Mhondoz	Celtik
Snowhand	Sandalio	J.J. Wezenberg
Frenzy	Kristian V Meyer	JiriDvorsky
Wayne Adams	Andres	Oliver Scharmann
Jukka Rouhiainen	Julian	Jostein Kolaas
Sam Wise	David Challis	Karl Asseily
Keith Bumford	Brad Rushworth	Hans Heerkens
Sonid Salissav	Alon Tall	kevin Hürlimann
Bradford Julihn	TRESPASSER	Reinhard Zeller
Kirin	Matt Miller-Fewer	Brad Stewart
Emil Philip	MARCELO TAKASE	AJD van der Valk
Joel Docker	James Roy	Erik Nielsen
Tino Costa	Boris G	Thomas Bakker

Harry vandeputte	Carlos Henrique Arantes	Pizzicato
Martin Janik	Theodoro	Christopher Foote
Luís Ferreira	Zamaraev Anton Vladislavovich	Robert Shaw
Carl Johnson	Max dahmer	Gregory Daskos
bounder	auo74	Salvador
Sven Bolin	Torian	Jason Story
Michael Gaskell	Arno Hasnæs	Scott
Nezu	Murray Thomas	Secret Squirrel
Kevin Vogel	Ron Harisch	Pier Giorgio Ometto
Laivynas	Dean Gardiner	William Forbes
JANIN Elie	Stanislav	Griffith Wheatley
Mikko Räsänen	Christian Noetzli	Donald Burnette
Maxim Lysak	HoperKH	Duncan Holland
klem	Johannes Wex	Karl Miller
Ian Linley	G W Aldous	Fabian Kraus
Jaws2002	Steve Butler	Miquel Tomàs Homs
Martin Heel	Sergey Goretsky	Ulrik Svane
desruels jean	Nathan	Christopher Ruse
Tom Lewis	Daniel Clewett	Goanna1
Michal Slechta	Drew Swenson	Dean Christopher Fortomaris
Joakim Söderman	DragonShadow	Stephen Turner
Matt Skinner	Andreas Bombe	charger-33
Mattias Svensson	Mario Binder	Roy Enger
Frank Zygor	Greg Pugliese	Ian Grayden
Mysticpuma	Richard Williams	Buster Dee
Andrey	Phil Rademacher	Antonio Salva Pareja
Steven Mullard	Gershon Portnoy	Robert Staats
Kaiser	Alexander Vincent	John McNally
Michael Leslie	Nicholas Sylvain-Obsidian	Håkan Jarnvall
Stewart Sayer	Tormentor	
	Zoltann	

Platinum Backers		
Kevin Gruber	Andrew Gluck	Chivas
Ilkka Prusi	Zinj Guo	Charles Ouellet
Ryan Power	Stephen Ptaszek	Harald Güttes
David Vigilante	MACADEMIC	Chekanschik
Adam Del Giacco	Ariel Morillo	Kodoss
Patrick	Michael Vrieze	Brad Edwards
Richard Boesen	Aaron Kirsch	dgagnon99
Mike Williams	Hen	Sam Higton
Robert Cattaneo	Shawn Godin	=tito=
Alvin Pines	G W Aldous	Rémy "Skuz974" STIEGLITZ
JOSHUA C SNIPES	Michael Brett	Andreas Gruber
Ole Jørgen Hegdal Lie	Tom Lucky Klassen	William Denholm
Ethan Peterson	KDN	322Sqn_Dusty
Jim Magness	Brian Thrun	theoretic
AirHog71	Martin Jaspers	AndK
Ralph Mahlmeister	John Guidi	Mike Abbott
Les Hillis	Tom Galloway	Aníbal Hernán Miranda
Dieter	Ian	Trond Bergsagel
Sean Trestrail	Dimitrios Syrogiannopoulos	Geoff Stagg
Johanan	Ryohei Yoshizawa	Alexander Osaki
Atle Fjell	TC1589	Nirvi
Eric W Halvorson	Federico Franceschi	M. Carter
DavidRed	mike parsell	David Block
Grant MacDonald	HolyGrail FxFactory	Alexis Musgrave
Richard Ashurst	Chad Owens	Necroscope
David Stubbs	Bobby Moretti	Mike Bell
Stefano Dosso	Melanie Henry	Richard Skinner
KLEPA	Christoffer Ringdal	Palmer T Olson
CAHUC Fabien	Ilya Shevchenko	Caulis Brier
	Soeren Dalsgaard	michael addabbo
	Luke Scalfati (tf_neuro)	

Krupi	John Bliss	Steven John Broadley
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	Pitti	JtD
	Simon Shaw	Robert S. Randazzo
Robert Sogomonian	Don Glaser	
Etienne Boucher	David Baker	
Ronald L Havens	John Douglass	
Dave	john	

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