SPITFIRE VC VS A6M2/3 ZERO-SEN

Darwin 1943

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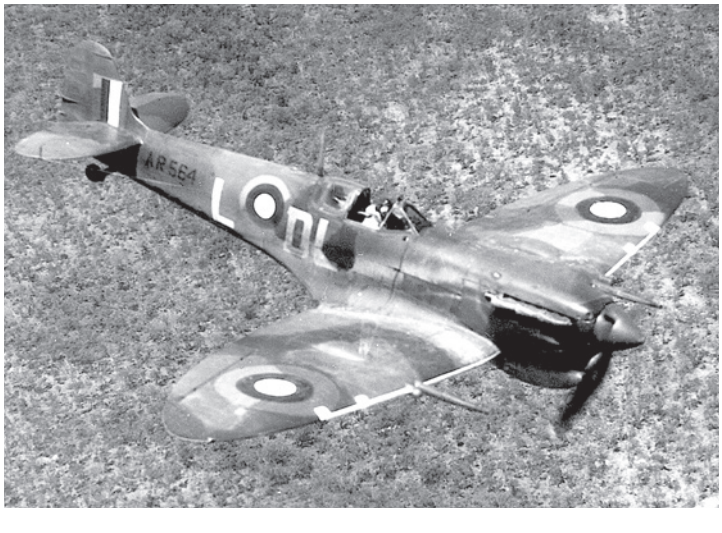
DESIGN AND DEVELOPMENT

During 1940–42, the Spitfire and the Zero-sen were the stand-out fighters of the European and Pacific theatres, respectively. Both became known as agile, high-performance aircraft that were feared by their adversaries. However, each came from opposite ends of the design spectrum. The Spitfire was a short-range defensive interceptor, while the Zero-sen was intended for long-range offensive missions.

The Vickers Supermarine Spitfire traced its lineage back to a private initiative by its designer, Reginald J. Mitchell, following which the Air Ministry subsequently wrote a formal specification around the aircraft. Prototype K5054, which flew for the first time on 5 March 1936, featured streamlined stressed-skin construction, a retractable undercarriage and, eventually, an armament of eight 0.303-in. Browning machine guns. The latter were mounted within the aircraft's distinctive elliptical wings and fired from outside of the propeller arc, thus avoiding the need for a synchronising mechanism and the complications that were associated with such devices.



No. 54 Sqn Spitfire VC AR564/DL-L over typical northern Australian terrain, its now-famous elliptical wings (a major factor in the aircraft's excellent performance characteristics as a fighter) being clearly visible from this angle. The unit's 'DL' fuselage code differed from the 'KL' codes it had long used when based in Britain. Flt Lt Robin Norwood may have had some influence in this choice as his wife's two given names were Dorothy Langridge. (Ralph Murphy)

Arguably the two standout features of the Spitfire prototype were its engine and wing. The Rolls-Royce PV-12 installed in K5054 evolved into the exceptional Merlin that proved capable of being developed into successively more powerful versions of the same basic engine. The elliptical wing shape helped give the Spitfire its characteristic appearance. Engineered primarily to fit the eight machine guns stipulated by the Air Ministry specification, it so happened to be one of the best fighter wings of its era. Indeed, during World War II Spitfires proved capable of sustaining dives of Mach 0.9, which was faster than that achieved by some early jet designs.

While Britain possessed a potentially world-beating fighter design in the late 1930s, it proved difficult to adapt the Spitfire's advanced stressed-skin design to mass production techniques. This in turn meant that the Vickers Supermarine aircraft was slow to enter service in quantity and was greatly outnumbered during the Battle of Britain by its less glamorous counterpart in Fighter Command, the Hawker Hurricane. In January 1942, it was Hurricanes that were rushed to the Far East and saw combat against IJAAF and IJNAF fighters and bombers as the latter swept all before them in the skies over Singapore, Java and Ceylon. Only in 1943 were Spitfires finally available to defend northern Australia.

The Mitsubishi A6M Zero-sen, meanwhile, was born from an IJNAF specification to replace the Mitsubishi A5M carrier fighter. Featuring stressed-skin construction like the Spitfire, the A6M was among the first mass-produced fighters to feature wing-mounted cannon in the form of two Type 99-1 20mm weapons. Although capable of inflicting considerably more damage than rifle-calibre machine guns, the Type 99-1 possessed a slow rate-of-fire and a low muzzle velocity, which reduced the weapon's effectiveness in aerial combat. The Zero-sen prototype first flew on 1 April 1939 – a full three years after the Spitfire. It showed exceptional performance characteristics, although the definitive A6M2 design did not emerge until December of that year in the form of the third prototype.

Spitfire VC EE853 (A58-146) on display at the South Australian Aviation Museum in Adelaide. This example was recovered from New Guinea (in 1973 by Langdon Badger), where it had served with the RAAF's No. 79 Sqn until written off in a landing accident in August 1943. However, it is identical to the Mk VCs that flew with No. 1 Fighter Wing over Darwin that same year. Note the barrel for the single 20mm cannon protruding from the port wing (a second cannon could be housed in the stub alongside it, although Spitfires flown in Australia had only a single 20mm weapon per wing) and the two ports further outboard for the 0.303-in. machine guns. (Author's collection)

SPITFIRE VC

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Only a relatively small number of personalised No. 1 Fighter Wing Spitfire VCs have been identified to date. Indeed, during the first months of the 1943 campaign, aircraft turnover was so high that there was limited opportunity for pilots to take 'ownership' of individual fighters. This particular aircraft, LZ846, was one of several No. 54 Sqn machines to carry the 'DL-N' code during 1942–44. A late arrival at RAAF Base Darwin, the aircraft was assigned to the unit on 17 July 1943. It became Flt Lt Norwood's aircraft shortly thereafter, and he soon had the 'robin's nest' artwork applied to its cockpit door. LZ846 was written off at RAAF Base Darwin on 9 January 1944 when its pilot, Flt Sgt A. E. Knapp, collided with a parked B-24D of the 380th BG after he veered off the runway on landing. Although the pilot escaped unscathed, the fighter was broken in half.

Japanese aircraft and weapons were given a numerical type designation related to a particular year in the Japanese calendar. 1940 was the Japanese year 2600, and so the A6M2 was officially known as the Type 0 Carrier Fighter Model 21. In Japanese, its popular name was Rei-sen – 'Zero-fighter' when translated into English. In 1942 the Zero-sen was given the Allied codename 'Zeke', and both were used interchangeably in combat reports from then on. However, the name 'Zero' was widely used during the war, and remains better known today.

Because of its lightness, the Zero-sen achieved good performance despite its Nakajima Sakae-12 radial engine generating a relatively modest 950hp. Many sacrifices were made to keep the weight down, with the A6M2 lacking both armour plating and self-sealing fuel tanks. It also carried just 60 rounds for each of its 20mm cannon. Because of these choices, and thanks to the installation of a 150-gallon internal fuel tank that could be augmented by a droppable 94-gallon external tank, the Zero-sen boasted an unmatched endurance when it entered frontline service with the IJNAF. However, it was a very finely balanced aircraft. Any increase in weight would significantly degrade its performance and range.

The original Spitfire I was comparable to the Zero-sen, as its Merlin III engine produced 1,030hp. Many upgrades were made to the design within a short time, including an increase in protective armour for the pilot, metal instead of fabric-covered ailerons and a metal variable-pitch propeller in place of the original fixed wooden Watts airscrew. The net result was additional weight that would have decreased performance had it not been for progressive increases in the power output of the Merlin engine. A key feature of the Spitfire's airframe was that it was able to absorb these numerous changes, which in turn meant it was the only British fighter to remain in production throughout the entire war.

The Spitfire VC was the model that fought in the skies over Darwin in 1943. The Mk V was the most numerous of all the Spitfire variants built, although by 1943 it was already being superseded in most theatres by the superior Spitfire IX. Numerous improvements meant that the Mk V was more than 500lb heavier than the original Spitfire I. The 'C' in VC referred to the 'universal' C-type wing that was designed to reduce manufacturing time and allowed for three different armament options. The 'C' wing featured either eight 0.303-in. machine guns, two 20mm cannon and four 0.303-in. machine guns or four 20mm cannon. Early-build Spitfire VCs were delivered with four 20mm cannon, but two of these weapons were usually removed once the fighter was in frontline service. Later, production would shift back to the B-type wing of two 20mm cannon and four 0.303-in. machine guns. The Spitfire Vs that fought over Darwin in 1943 were fitted with B-type wings, despite being designated Mk VCs.

The Australian aircraft were powered by Merlin 46 engines rated at 1,210hp on take-off. Crucially, this version of the Rolls-Royce powerplant boasted a single-stage supercharger optimised for high-altitude performance. This meant the Mk VCs gave their best performance at altitudes exceeding 18,000ft thanks to the generation of an extra 200hp by the supercharger.

The RAAF aircraft are sometimes further specified as being Spitfire VC Tropicals, which refers to modifications intended to suit operations in the demanding northern Australian climate. Most obvious of these was the provision of a Vokes filter, which prevented excessive dust entering the engine. Fine dust was an engine killer, for sand

entering the Merlin caused excess wear, lower power output and a shortened lifespan. To battle the dust the Vokes filter was added. Housed in a beard-like faring under the fighter's nose, it was not popular with pilots. While the filter reduced the Mk V's top speed, its benefits far outweighed any reduction in performance caused by excessive wear.

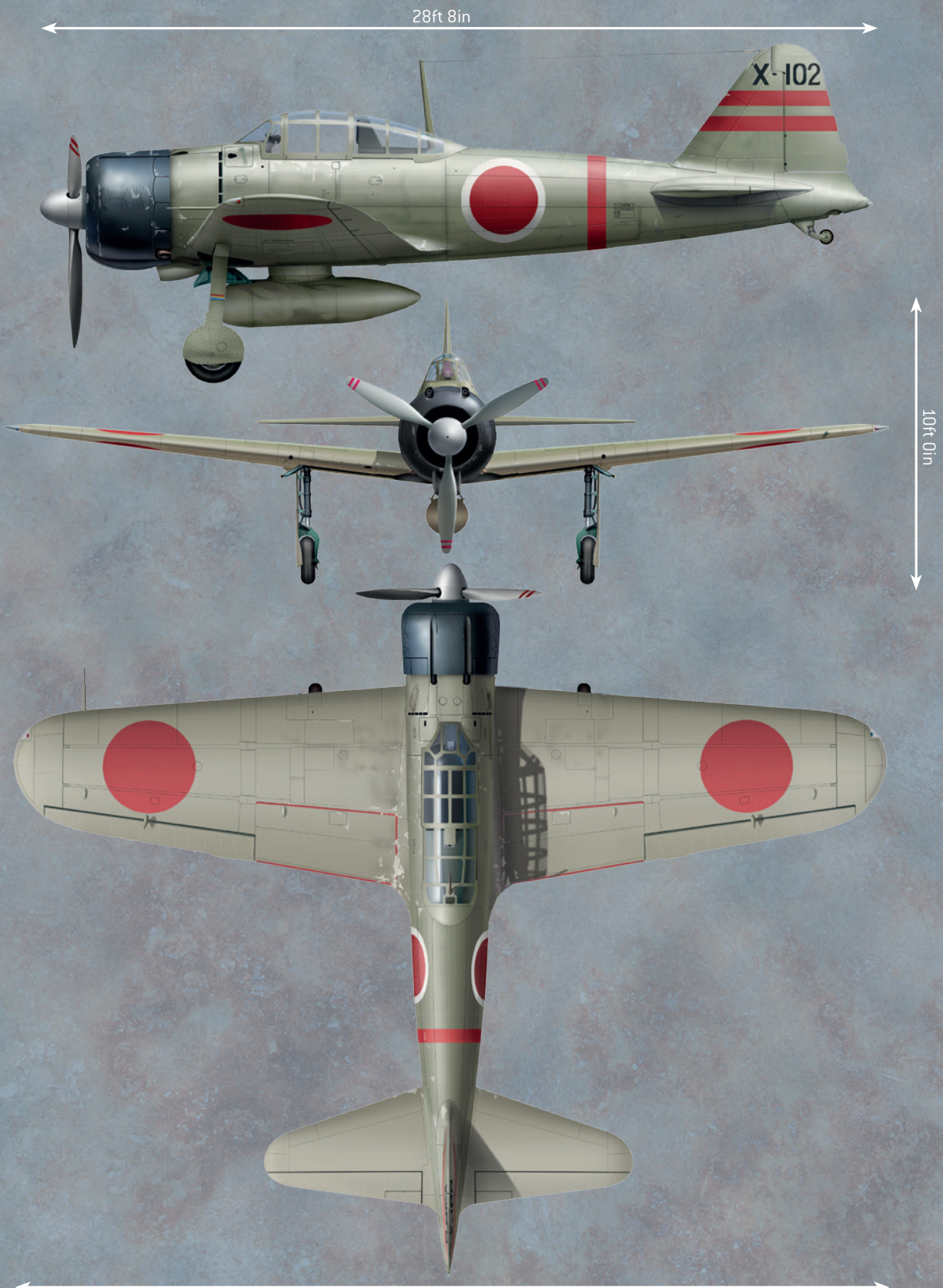
When the RAAF first flight-tested its Mk VCs near Sydney in late 1942, it was believed they were up to 20mph slower than earlier standard Spitfire VA/Bs. The Vokes filters were blamed, but subsequent tests proved they only had a marginally negative effect on performance. The actual cause of the poor performance was more complex, being related to the Merlin 46s only generating their maximum output at high altitude. Actual experience in Darwin would soon put these concerns into perspective, as differences in performance between individual aircraft could be even more significant, depending on a variety of factors such as airframe age, engine wear and maintenance history.

Other tropical items were also added. Fitted in the rear fuselage behind the cockpit was a tank for 1.5 gallons of drinking water, along with a container of flying rations, an emergency tool roll, survival equipment and a signal pistol with cartridges.

The original A6M2 model of the Zero-sen, fitted with the 950hp Sakae-12 engine, was the variant that enjoyed so much success during 1940–42. The Japanese commenced production of the improved A6M3 in early 1942, the aircraft being

On 27 December 1942, this A6M3 of the Tainan Kokutai was found abandoned at Buna airstrip in New Guinea by advancing Allied troops. Built by Mitsubishi in June of that year, the fighter was adorned with the Kanji subscript Hokuku – 870 (Ko Gen), indicating that this fighter had been donated by a civilian volunteer group possibly from occupied China. It was subsequently shipped via barge, along with parts from five other A6M3s found at the site, to Eagle Farm in Brisbane, Queensland, in February 1943. The aircraft was returned to airworthiness by TAIU-SWPA personnel through the incorporation of missing parts obtained from other abandoned Zero-sens at Buna. (NARA)

A6M2 ZERO-SEN MODEL 21



The Buna A6M3 was briefly test flown from Eagle Farm following a six-month rebuild that saw parts from six Zero-sens combined to make one airworthy aircraft – the fighter is seen here in flight off the Brisbane coast in August 1943. By the time it flew trials against a Spitfire VC (which confirmed the superior manoeuvrability of the Japanese machine), the comparative performance of the two types was already well known following several months of hard-fought combat. Among the changes introduced with this version of the Zero-sen were squared-off wingtips that improved the fighter's roll rate and speed in a dive (AWM).

powered by the improved Sakae-21 that featured a two-stage, two-speed supercharger that increased the engine's output to 1,130hp. However, the modifications needed to accommodate the longer and heavier Sakae-21 (specifically a new cowling with a revised carburettor air intake) meant that endurance and manoeuvrability were sacrificed for only marginal improvements in speed, aileron control, roll rate and performance in high-speed dives. The A6M3's lateral control was achieved by eliminating the wing-folding mechanism and fairing over the wingtips, shortening the wingspan by almost three feet and reducing the span of the ailerons. Codenamed 'Hamp' by the Allies (the aircraft was originally given the codename 'Hap', but after intervention by the Commanding General of the USAAF, Gen Henry 'Hap' Arnold, it was changed to 'Hamp'), no A6M3s were ever encountered over Darwin, owing to the variant's inferior range when compared to the older A6M2.

So how did the Spitfire VC Tropical compare to the Zero-sen? This can be answered with some authority following comparative flight testing between the two types that took place in Australia in August 1943. The Zero-sen in question was an A6M3 'Hamp' that had been found abandoned at Buna airstrip in New Guinea by advancing Allied troops on 27 December 1942. Assigned to the Tainan Kokutai, the fighter was shipped via barge, along with parts from five other A6M3s found at the site, to Brisbane, in Queensland. Moved to nearby Eagle Farm in February 1943, the aircraft was returned to airworthiness by Technical Air Intelligence Unit-South West Pacific (TAIU-SWPA) personnel over subsequent months through the incorporation of missing parts obtained from the remaining abandoned Zero-sens at Buna.

The trials confirmed that due to its light weight and lower wing loading, the Zero-sen was generally more manoeuvrable than the Spitfire. While the latter enjoyed some advantages in speed, the Zero-sen had far better acceleration. The conclusion of the two test pilots that flew the aircraft was clear:

LEFT

A6M2/3 Zero-sens of the 202nd Kokutai carried X-prefixed serial numbers on the tips of their tails, as had the aircraft used by its predecessor unit, the 3rd Kokutai. Aircraft from both units were painted in standard grey-green overall, with a black engine cowling. This particular machine also had a white outline around its hinomaru, identifying that it was a Nakajima-built Zero-sen rather than one from Mitsubishi. A feature of most Zero-sen units, including the 202nd Kokutai, were command stripes – either vertical or diagonal – on the fuselage, along with horizontal stripes on the fin. These served to identify leaders and sub-leaders within the unit when in the air. IJNAF fighter pilots relied heavily on such visual aids during combat owing to the lack of functioning radio equipment in their A6M2/3s.

> Both pilots consider the Spitfire is outclassed by the Hap [Hamp] at all heights up to 20,000ft. The Spitfire does not possess any outstanding qualifications which permits it to gain an advantage over the 'Hap' ['Hamp'] in equal circumstances.

This finding might have been a surprise for some, given that the Spitfire was a machine that had gained such a fine reputation for manoeuvrability in the European theatre. Furthermore, the trials were against the A6M3, which was less manoeuvrable than the A6M2. However, performance is relative, and the message was clear to Spitfire pilots – don't try to dogfight with a Zero-sen.

The main advantage held by the Spitfire VC over the A6M3 was its superior performance at high altitude. The combat ceiling of the IJNAF fighter was established at 32,500ft, while that of the Spitfire VC was 37,000ft. The heavier Spitfire could dive faster, so if it had the height advantage it could make diving attacks with relative impunity. The Spitfire pilot then had the choice of zooming up in preparation for another diving attack or continuing the dive and disengaging if the situation was unfavourable. However, these test results were only released *after* the 1943 air campaign over Darwin had been fought. The RAAF pilots would learn the same lessons in combat.

Other key design differences between the Spitfire VC and the A6M2/3 included the undercarriage and engine type. The Zero-sen, intended for carrier operations, had a wide undercarriage that also made it highly suitable for rough field operations. The relatively narrow track of the Spitfire undercarriage proved quite the opposite, and in northern Australia landing accidents were common until pilots got used to the conditions.

Painted a turquoise colour, the sheet of armour plating fitted as standard behind the pilot's seat is clearly visible in this photograph of Spitfire VC EE853's restored cockpit. Crucially, the A6M2 lacked any such armoured protection for its pilot. The padding in the headrest immediately above the plating was needed to cushion the pilot's head when it jerked back after the throttle was opened and the Merlin 46's supercharger kicked in at altitude. (Author's collection)

Both aircraft types were married to high performance powerplants in the Sakae and the Merlin. The latter was liquid-cooled, and this cooling system proved prone to leaks or combat damage. It also created an additional maintenance burden in an environment where engineering resources were sparse and routine mechanical procedures were often carried out in the open. The air-cooled radial Sakae engine, on the other hand, was simpler and proved a lot more rugged in service. IJNAF groundcrews were able to perform full overhauls with relatively basic facilities, and the Zero-sen developed an exceptional reputation for reliability. During operations against Darwin, several hours of over-water flying were required for each mission – usually a risky proposition for a single-engined type. However, losses were relatively uncommon and even combat-damaged machines usually managed to return to the 202nd Kokutai's main forward operating base at Penfoie airfield in Koepang, on the island of Timor.

TECHNICAL SPECIFICATIONS

Both the Spitfire and Zero-sen were conventional monoplane fighters of similar layout. The Japanese machine had a raised canopy and cut-down rear fuselage decking which gave the pilot outstanding all-round visibility. By comparison, the Spitfire pilot's view was restricted by the raised fuselage directly behind the headrest, although this was partially offset by a bulged canopy and a rear-view mirror mounted on the windscreen framing.

Both fighters were comparable in size, although the Zero-sen had a wider wingspan, but was slightly shorter in overall length. Together with a lighter weight, this meant that the Japanese fighter had a significantly lower wing loading, and hence was more manoeuvrable. The Spitfire, however, could fly higher than the Zero-sen and was optimised for high-altitude performance. It could also achieve faster speeds in a dive, meaning that an altitude advantage was critically important if a Spitfire pilot hoped to achieve success upon entering aerial combat.

The other key difference between the two types was in respect to endurance, and in the expansive Pacific theatre a healthy range was a fundamental requirement for any mission profile. Unfortunately for the units flying the Spitfire VC in the defence of northern Australia, the fighter had a very modest range, even when using a drop tank. This duly imposed significant limitations on operations over Darwin in 1943. On the other hand, the range of the A6M2 Zero-sen was outstanding, and this had been a major factor in its unmatched success in the early part of the Pacific war.

	Spitfire VC Tropical	A6M2 Zero-sen
Powerplant	1,210hp Rolls-Royce Merlin 46 (approximately 1,400hp at altitude)	950hp Nakajima Sakae-12
Performance		
Max speed	354mph at 19,000ft	331mph 14,930ft
Service ceiling	37,000ft	32,500ft
Weights		
Empty	5,081lb	3,704lb
Loaded	7,170lb	6,164lb
Dimensions		
Span	36ft 10in.	39ft 4.7in.
Length	29ft 11in.	28ft 8in.
Height	11ft 5in.	10ft 0in.
Wing loading	28lb/ft^2	22lb/ft^2
Fuel		
Internal fuel	84 gallons	150 gallons
Drop tank	30 gallons	72 gallons
Combat radius	200 miles	600 miles

ARMAMENT

At first glance the armament of the Spitfire VC and the A6M2 Zero-sen was almost identical – both had two 20mm cannon backed up by a secondary armament of machine guns. However, the Spitfire had twice the amount of ammunition and two extra machine guns. While the 0.303-in. Browning machine guns and the 7.7mm Type 97 weapons were comparable in terms of performance, there were some important differences between the Spitfire VC's Hispano Mk II cannon and the A6M2's Type 99-1.

A 94-gallon drop tank from a Zero-sen, which was jettisoned over northern Australia prior to the fighter entering combat with No. 1 Fighter Wing Spitfires. This tank was more than twice as large as the 30-gallon drop tank used by the considerably shorter-ranged Spitfire VC. (Author's collection)

One of No. 1 Fighter Wing's Spitfire VCs undergoes maintenance shortly after its reassembly at RAAF Base Laverton, Victoria, in early 1943. Like many other Spitfires sent out from Britain at this time, the aircraft is still wearing its factory-applied two-tone Desert camouflage scheme. They were soon painted in more appropriate colours and had unit codes added prior to their flight north to Darwin. (Andrew Thomas Collection)

The A6M2 Zero-sen's Type 99-1s were licence-built versions of the Swiss Oerlikon FF design, which was one of the first auto-cannons to be small and light enough to be fitted in the wing of a fighter aircraft. However, this design was not ideal for air-to-air combat, owing to its relatively low muzzle velocity that made split-second deflection shots very difficult to achieve. Indeed, high-scoring IJNAF Zero-sen ace Saburo Sakai was famously quoted as saying that using the Type 99-1 cannon in aerial combat was like 'trying to hit a dragonfly with a rifle'. Nevertheless, the weapon proved rugged and reliable in service.

The firepower of the Type 99-1 cannon made the Zero-sen particularly devastating during strafing attacks against stationary aircraft. The incendiary effect of the 20mm rounds would often ignite fuel tanks in targeted aircraft – even if the tanks were empty, the residual fumes alone could cause an explosion. The manoeuvrability of the Zero-sen made it a very good gun platform for strafing, and skilled pilots could use the machine guns as 'sighters' to confirm their aim before

The A6M2 was armed with two 20mm Type 99-1 cannon, a single weapon being housed in each wing just outboard of the propeller arc, and two cowling-mounted Type 97 machine guns whose breeches protruded into the cockpit. The cannon had a relatively slow maximum cyclic rate of fire of 490 rounds per minute, which meant that most aerial victories credited to A6M2 pilots were achieved using the quicker firing Type 97 machine guns, which had a maximum cyclic rate of fire of 900 rounds per minute. (NARA)

firing the cannon – a tactic that helped to offset the limited amount of 20mm ammunition carried.

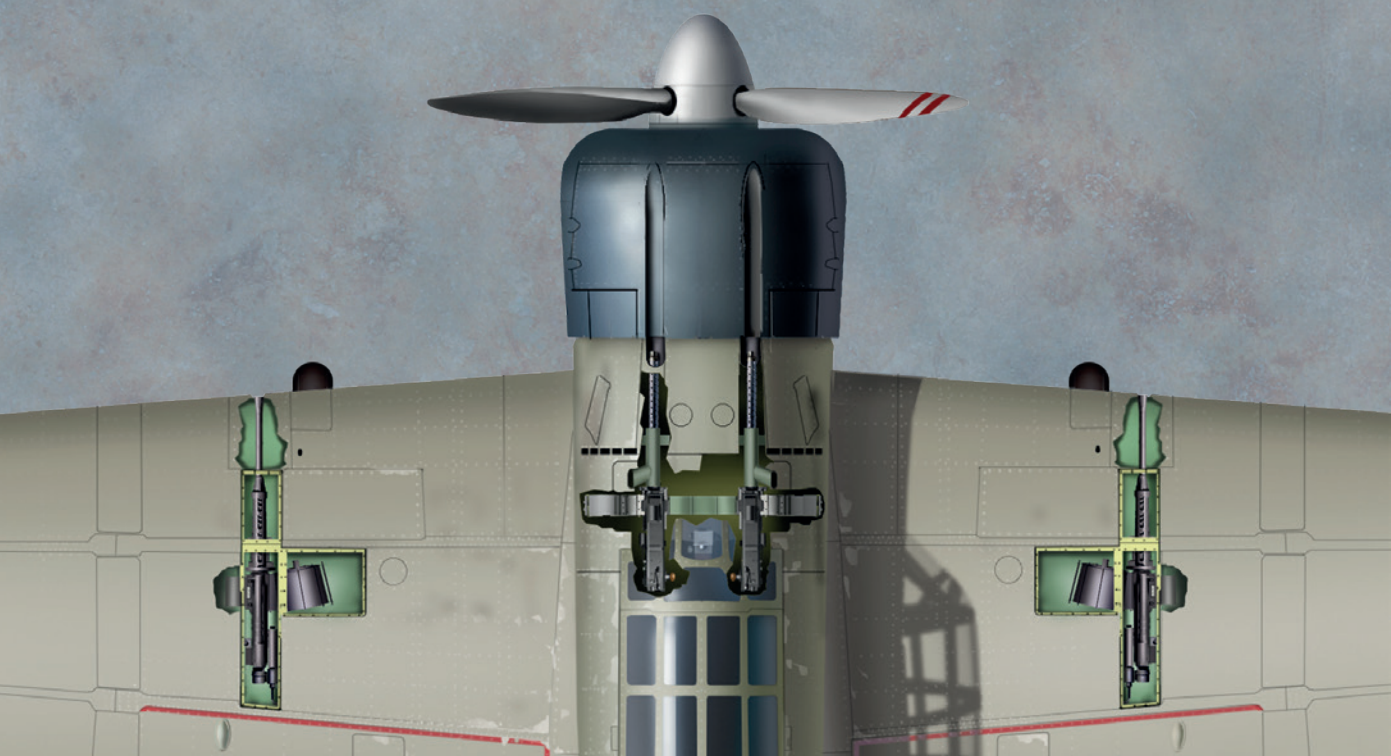
The Spitfire VC mounted the standard British Hispano auto-cannon, which had a faster muzzle velocity and better rate of fire than the Type 99-1. It proved highly destructive against largely unarmoured Japanese aircraft that had already demonstrated their vulnerability to the much smaller US 0.50-cal machine gun round as used by the P-40E's battery of Browning M2 machine guns. However, because of the belt-fed ammunition, as well as other design issues, the Hispano as used over Darwin was a somewhat delicate weapon and was prone to failures. Furthermore, if one cannon failed, the other was almost useless as the unilateral recoil would yaw the aircraft and throw off the pilot's aim.

IN SERVICE

Since the start of the European war, Spitfires had operated from well-resourced airfields in Britain that were close to engineering support and centres of aircraft

A6M2/3 ZERO-SEN MODEL 21 ARMAMENT

The A6M2/3 was armed with two Type 99-1 20mm cannon mounted in each wing just outboard of the propeller arc, and two Type 97 7.7mm machine guns (based on the British Vickers machine gun) in the upper fuselage decking. The latter weapons, with ammunition boxes installed on either side carrying 500 rounds per gun, were synchronised to fire through the propeller. The cannon had a relatively slow maximum cyclic rate of fire of 490 rounds per minute, with each ammunition canister holding just 60 rounds per gun. In practice, this meant the Type 99-1 was a deadly weapon during strafing attacks, but it was more difficult to use for deflection shots during dogfights. In contrast to the Hispano cannon used by the Spitfire, the ammunition for the Type 99-1 was fed from a circular drum. The weapon proved both robust and reliable in service.



Groundcrew service a No. 54 Sqn Spitfire VC between flights at RAAF Base Darwin. No. 1 Fighter Wing struggled to keep its Spitfires serviceable, owing to their airfields being hundreds of miles from established engineering support facilities. This in turn meant that the wing's groundcrews faced a steep learning curve when it came to ensuring that a sufficient number of airworthy Spitfires were available to defend Darwin adequately in the first months of 1943. Here, the airman standing on the wing root of the fighter is securing the filler cap for the fuel tank fitted immediately in front of the cockpit. His shirtless colleague perched atop the open cockpit hatch is checking the operability of the port aileron, which has been raised at the trailing edge, by moving the control column. (Bob Alford)

manufacturing. This had enabled many design changes to be introduced quickly and validated under combat conditions. However, the Spitfire VCs of No. 1 Fighter Wing would be based in a remote part of Australia, far distant from the RAAF's key technical centres, let alone those in Britain. It took the best part of a year for this support chain to become fully effective, so during 1943 the Spitfires in Darwin did not have the best technical support possible. There were numerous shortages of spare parts and even basic consumables such as drop tanks.

Technical problems also plagued the aircraft during the early months of its service introduction in Australia, with the worst of these being ineffective gun heaters. In Europe, it was found that oil in the Spitfire's guns could freeze in conditions of extreme cold. A modification was introduced whereby hot engine exhaust gases were ducted to the guns by means of aluminium piping. This was generally successful, although the 20mm Hispano cannon used in the Spitfire VC needed a heavier duty system to eradicate the problem. It was soon discovered that the aluminium piping was prone to cracking because of engine vibration, necessitating its replacement by stronger steel components.

	Spitfire VC Tropical	A6M2 Zero-sen
Primary – cannon	2 x 20mm Hispano II	2 x 20mm Type 99-1
Ammunition	belt-fed	drum
Rounds per gun	120	60
Rounds total	240	120
Secondary – machine guns	4 x 0.303-in. Brownings	2 x 7.7mm Type 97s
Rounds per gun	500	500
Rounds total	2,000	1,000