



Fire Protection Systems in the Ilyushin Il-28: The Only Jet Bomber in the Czechoslovak and Czech History

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Abstract:

The article is focused on fire protection systems in the now historic Ilyushin Il-28, the only aircraft in the history of Czechoslovakia and the Czech Republic designed solely as a bomber and equipped with jet engines. The article presents statistics of air accidents of this type of aircraft and their causes, emergency procedures for on-board fires and a description of the fire-fighting and inert gas systems. Due to difficulties in accessing the now scarce resources related to historical information of technical nature on the subject, the contents of the following paragraphs can be considered unique.

Keywords:

Czechoslovak People's Army; carbon dioxide; fire; jet bomber; inert gas system.

1. Introduction

The Ilyushin Il-28 (NATO reporting name "Beagle") was a Soviet-built three-seat twin-engined jet bomber, torpedo bomber and surveillance aircraft. It operated in the Air Force of the Czechoslovak People's Army in 1955–1973 (in four variants: Il-28, Il-28U, Il-28R, and Il-28RT/Il-28RTR) (see Tab. 1 and Fig. 1). In former Czechoslovakia, two variants were license-built as B-228 (the original Il-28) and CB-228 (the original Il-28U). After 29th September 1956, it was ordered to use original designation for all Soviet combat military aircraft in all documents, in this case Il-28 with suffixes indicating aircraft variants. The crew consisted of three men: a pilot, a navigator-bombardier and a radioman-gunner.

The first three variants mentioned above were delivered from the Soviet Union. They included: the Il-28 (front-line bomber, фронтальной бомбардировщик in Russian; in older professional literature also referred to as Il-28B), the Il-28U (trainer bomber, учебно-тренировочный бомбардировщик in Russian) and the Il-28R (front-line scout,

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фронтальной разведчик in Russian). In historical records, seventy-seven aircraft are documented to have been delivered, but the estimates vary between sixty and one hundred and fifty aircraft [3]. The Il-28RT (for radio reconnaissance) and Il-28RTR (for radio jamming) variants were modifications of the variants delivered from the Soviet Union built in Czechoslovakia in the early 1960s. The accurate differentiation of the two variants in terms of their equipment is still subject to uncertainty. The archival documents from that period are inconclusive to show strict difference in the equipment as each modified aircraft was in principle a prototype. Assume, however, that an estimate based on the known and proven equipment of the two modifications is correct. In the Czechoslovak People's Army, the Il-28 was in service as a bomber until 19th May 1965 when the last bomber unit, the 25th Bomber Regiment, was closed. After that date until its decommissioning, it was used only for photo and radio reconnaissance, radio jamming and towing of practice targets in aerial shooting trainings.

It is an interesting fact that in older Czechoslovak literature, the Il-28 is sometimes referred to as a “nuclear bomber”. It should be noted that no variant of the aircraft that operated in former Czechoslovakia conformed to this specification and no Czechoslovak crew was ever trained for a mission of that kind. Only the Il-28A variant was structurally modified and equipped for combat use of nuclear weapons, but it never operated in the Czechoslovak Air Force [3].

Tab. 1 Selected tactical and technical data [3], [12]

Specifications	
Wingspan, length, height	21.45 m, 17.65 m (excluding stern cannon barrels), 6.7 m
Wing area	60.8 m ²
Aspect ratio	7.55
Max. fuel capacity	6600 kg (8000 l)
Max. takeoff weight	23200 kg
Max. speed in level flight	900 km/h (at an altitude 5200 m)
Rate of climb	15 m/s
Takeoff run	875–1150 m
Landing run	1170 m
Ceiling	12500 m (with takeoff weight 18400 kg; climb time 44.6 minutes)
Range	2400 km (with takeoff weight 20000 kg, 8000 l of fuel, at an altitude 10000 m; flight time 3 hours 38 minutes)
Number and type of powerplants	2 x Klimov VK-1
Static thrust of the powerplants	26.478 kN (2700 kp) (at 11560 rpm for takeoff mode)
Static net fuel consumption	0.1091 kg/Nh (for takeoff mode)



Fig. 1 Vintage photograph of the Il-28 [3]

2. Overview of Occurrences and Most Common Causes of Fire

During eighteen years of Il-28 active service in the Czechoslovak Air Force, twenty-six occurrences happened that could be classified as “disasters“, “accidents“ or “damage”.

An air disaster is an occurrence associated with aircraft destruction and with loss of human lives. An accident is an occurrence associated with aircraft destruction or severe damage requiring overhaul, but without loss of human lives. A damage event is an occurrence not requiring an overhaul where repair time did not exceed fifty hours for twin-engined aircraft (definition used until 1960) or an occurrence after which the aircraft was repairable even for the cost of the overhaul (definition used after 1960). Also, after 1960, the time limit for repairing minor damage of twin-engined aircraft was raised to one hundred hours. Occurrences not meeting the above definitions were considered of minor importance and, therefore, they were registered only at the respective military units. This is the reason why both tracing and analyzing them statistically is, with the passing of time, increasingly difficult and sometimes impossible now.

In 1955–1973, seven disasters, three accidents and sixteen damage events occurred, in which seventeen pilots were killed and ten aircraft were destroyed – six Il-28s, three Il-28Rs and one Il-28U. The greatest number of disasters and accidents (two disasters and two accidents) were reported in 1957. That year also saw the greatest number of crew members killed (six pilots). The greatest number of damage events (seven damage events) were reported in 1959. More detailed information on the occurrences can be found in [3], [10], [11].

Two occurrences involved a fire of Klimov VK-1 engines: a disaster near Bezuchov, approximately 10 kilometers east of the town of Přerov, on 19th November 1957 and a disaster at the Přerov airport on 19th January 1965 (see [3], [10], [11]).

Archival documents on air accidents and recollections by flight and non-flight staff (see, for example, [3], [10], [11]) suggest that the causes of Klimov VK-1 engine fires may be classified into two categories: engine mechanical failures and non-compliance with recommended procedures of engine operation by flight or non-flight staff.

A lot of experience in this regard had been gained earlier by operating MiG-15s that had used the same type of engine [4], [5], [6].

Fuel or hydraulic oil line leaks are typical examples of mechanical failures. The escaped fuel or hydraulic oil in contact with hot parts of the engine would cause a fire. In extreme cases, fire was also caused by the engine combustion chamber destruction [1].

Failing to perform dry motoring after a wet start failure on-ground or in-flight is an example of non-compliance with recommended procedures. After an unsuccessful attempt to start the engine, there was unburned fuel accumulated in the engine. If dry motoring procedure was not performed to evacuate residual fuel or vapors from the engine, introduction of more fuel and its initiation would cause a fire [10], [11].

3. The Fire-fighting System

The Ilyushin Il-28 was equipped with a fire-fighting system consisting of two main segments: the Klimov VK-1 engines protection segment and the fuel tanks protection segment (see . 2).

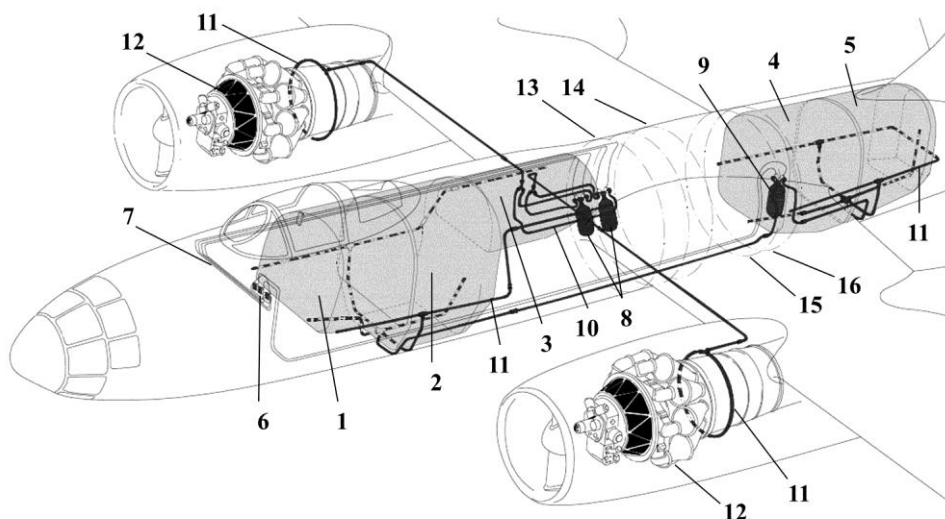


Fig. 2 Ilyushin Il-28 fire-fighting system [2]: (1) fuel tank no. 1, (2) fuel tank no. 2, (3) fuel tank no. 3, (4) fuel tank no. 4, (5) fuel tank no. 5, (6) fire protection system control panel in the cockpit, (7) electrical wiring between the control panel and fire extinguishant pressure bottle pyrocartridges, (8) extinguishant pressure bottles no. 1 and 2, (9) extinguishant pressure bottle no. 3, (10) extinguishant distribution tubing, (11) extinguishant spray manifolds, (12) VK-1 jet engine, (13) partition no. 23, (14) partition no. 25, (15) partition no. 28, (16) partition no. 29

The engine protection segment consisted of two eight-liter (5.7 kg) fire extinguishant pressure bottles with carbon dioxide located on the right side of the fuselage between partitions no. 23–25, distribution tubing, circular spray manifolds around the engine units and total of ten bimetallic membranes (fire detectors) to evaluate the static reaction temperature range of 110–140 °C. Five bimetallic cells were placed on each engine unit. Each fire bottle was fitted with two metallic membrane pyrocartridges that facilitated distribution of fire-extinguishing agent from either fire bottle to either engine unit, if necessary. Detection of an engine fire was indicated by two red warning lights (one for each engine) on the left panel in the cockpit (see Fig. 3). The pilot then

manually activated the fire-extinguishing equipment utilizing one of the fire bottles with the extinguishing agent. If the fire of the engine unit was not extinguished within 40–60 seconds (the warning signal continued), the pilot manually activated the second fire bottle with the extinguishing agent. This duplicate system was very effective. After the fire was extinguished, the engine unit was not allowed to re-run. If extinguishing the fire was unsuccessful, the crew had to abandon the aircraft.

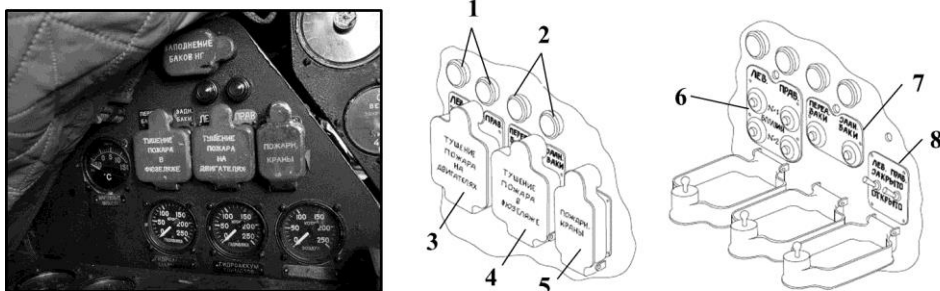


Fig. 3 Ilyushin Il-28 fire-fighting system control panel [2]: (1) fire warning lights for right and left engines, (2) fire warning lights for forward and aft fuel tanks, (3) cover of push button switches for the activation of engine fire extinguishing system with the extinguishant pressure bottle no. 1 or 2 , (4) cover of push button switches for the activation of forward or aft fuel tanks fire extinguishing system with the extinguishant pressure bottle no. 3, (5) cover of toggle switches for right and left engine fuel system fire valves, (6) push button switches for the activation of engine fire extinguishing system with the extinguishant pressure bottle no. 1 or 2 , (7) push button switches for the activation of forward or aft fuel tanks fire extinguishing system with the extinguishant pressure bottle no. 3, (8) toggle switches for right and left engine fuel system fire valves

The fuel tanks protection segment consisted of one eight-liter (5.7 kg) fire extinguishant pressure bottle with carbon dioxide located in the fuselage between partitions no. 28 and 29, distribution tubing, and spray manifolds placed between the outer wall of the tanks and inner wall of the fuselage. Four of five fuel tanks were protected in this manner. The smallest tank no. 3 in the middle had no protection because it was assumed it would have been empty by the time of combat. Spray manifolds connected to the fire bottle were also placed inside of all five fuel tanks to keep constant overpressure of carbon dioxide above the fuel surface. It was a system of fire and explosion prevention in case the fuel tanks would have got hit during combat. The fuel tanks had rubber covering and were designed as self-locking [2], [12].

4. The Inert Gas System

Despite the fact that the inert gas system was mentioned separately in the original Il-28 technical documentation [2], it can be classified clearly as one of the fire protection elements of the aircraft.

The inert gas system was a system of fire and explosion protection of fuel tanks in case of their perforation (for instance, as a result of being hit by enemy ammunition during combat).

The system consisted of one eight-liter (5.7 kilograms) pressure bottle with carbon dioxide (CO₂) inert gas located in the left fuselage between partitions no. 23 and 24, two calibrated pressure reducing valves, distribution tubing, spray manifolds placed inside the fuel tanks no. 2 and 4 and discharge tubing (see Fig. 4).

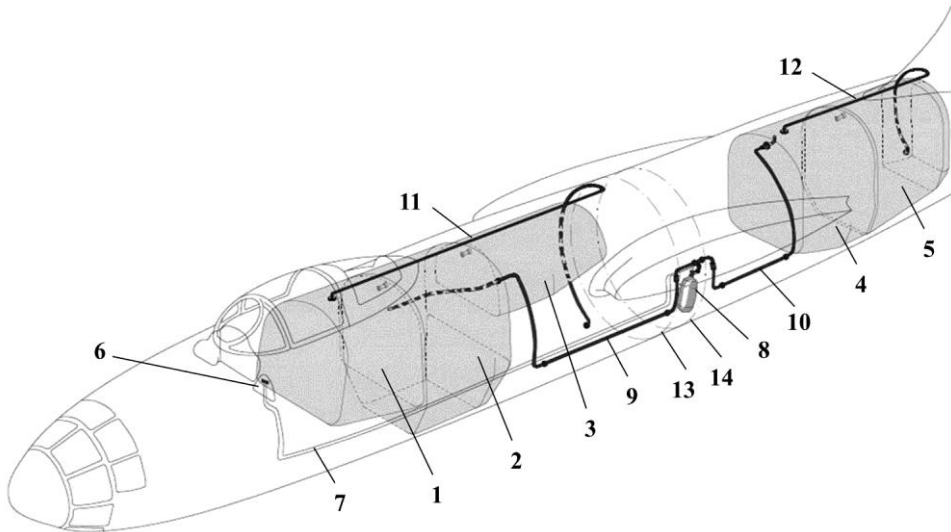


Fig. 4 Ilyushin Il-28 inert gas system [2]: (1) fuel tank no. 1, (2) fuel tank no. 2, (3) fuel tank no. 3, (4) fuel tank no. 4, (5) fuel tank no. 5, (6) inert gas system control panel in the cockpit, (7) electrical wiring between the control panel and pyrocartridge of the pressure bottle with CO₂ inert medium, (8) pressure bottle no. 4 with CO₂ inert medium, (9) supply tubing for forward fuel tanks, (10) supply tubing for aft fuel tanks, (11) discharge tubing for forward fuel tanks, (12) discharge tubing for aft fuel tanks, (13) partition no. 23, (14) partition no. 24

In case of fire or a fuel leak, apart from the fire-fighting system, the pilot could activate the inert gas system using a switch located on the utility panel (above the fire-fighting system switches) on the left of the instrument panel in the cockpit.

The switch electrically activated the pyrocartridges on the pressure bottle with the inert carbon dioxide (CO₂) gas. The inert gas was delivered through the calibrated pressure reducing valves, distribution tubing and spray manifolds and distributed above the fuel surface in tanks no. 2 (forward) and 4 (aft). The reducing valves were continuously heated to prevent them from freezing. Adjacent fuel tanks no. 1 (forward) and 5 (aft) were supplied with CO₂ through connecting tubes. Only the smallest tank no. 3 in the middle had no protection because it was assumed it would be empty by the time of combat (see above). The excess pressure of CO₂ was drawn off by drainage pipes from tanks no. 1 and 4 outside the fuselage into the atmosphere. The overpressure above the fuel surface in tanks was constantly kept in the range of 0.1–0.15 kg/cm², i.e. approximately 9.8–14.7 kPa of the inert gas. The system functioned continuously until the gas in the pressure bottle was exhausted.

The gas pressure in all fire-fighting and inert gas system pressure bottles changed approximately exponentially with ambient temperature in the range of 10–100 kg/cm², i.e., approx. 1–9.8 MPa (for ambient temperatures ranging from – 40 °C to + 40 °C) [2].

5. Fire Emergency Procedures

The fire warning and control panel was located on the main instrument panel left side in the pilot's field of vision. If the system was functional, it was unlikely that the pilot should fail to notice the warning lights.

Upon the detection of a fire in the engine unit, a warning light was illuminated and the pilot had to perform chronologically the following four operations:

1. Switch off the fuel supply into the affected engine unit by pulling the fuel shut-off cock lever to the CLOSED position (see Fig. 5 below).
2. Turn off the fuel pump for the affected engine unit by setting the fuel system fire valve toggle switch to the CLOSED position. As a rule, the pilot waited a few seconds to see whether the engine unit fire was extinguished. If the fire persisted, steps III. and IV. followed (see below).
3. Reduce the flight speed to 300–350 km/h as quickly as possible.
4. Activate the fire extinguishing system by pressing the pyrocartridge activation push button for the pressure bottle corresponding to the affected engine unit. The pyrocartridge activation push button was placed under a cover labeled “engine fire extinction” on the main instrument panel left side below fire warning lights.

If the fire was not extinguished within 40–60 seconds, the pilot activated the pyrocartridge of the second pressure bottle by pressing the corresponding push button and he had to wait other 40–60 seconds. If extinguishing the fire was successful, the engine unit was not allowed to re-run because of the risk of another fire outbreak. It was possible to maintain a horizontal flight and land safely even with one functional engine. If extinguishing the engine fire was unsuccessful, the crew had to either perform forced landing or eject depending on the current flight altitude.

If a fuel tank fire occurred, the pilot had to press push buttons placed under the second (middle) cover to activate the pressure bottle no. 3 pyrocartridges for extinguishing the forward or aft fuel tanks fire. Fuel transfer between tanks, if it was necessary, had to be carried out very cautiously to keep the aircraft balanced, which was very important when flying at low speeds and especially when landing.

For emergency evacuation, the aircraft was fitted with ejection seats for the pilot and the navigator only. In case of emergency, the gunner-radioman whose position was in the aft of the fuselage had to use a hydraulically operated hatch located behind the tail turret [2], [7], [8], [9].

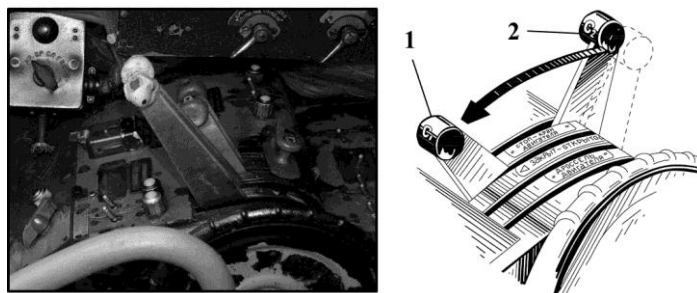


Fig. 5 Fuel shut-off cock levers on the Il-28 cockpit left hand side [7]: (1) C_1 fuel shut-off cock lever for the right engine, (2) C_2 fuel shut-off cock lever for the left engine

6. Conclusion

In summary, from military and historical perspective, the Il-28 came relatively late in the former Czechoslovakia, that is, when it was already outdated in design and technology in its class. Despite the existence of a Soviet nuclear bomber variant, in Czechoslovakia it operated only as a conventional bomber and later it was used for photo and radio reconnaissance. After the last Czechoslovak People's Army bomber unit was closed in 1965, the concept of Czechoslovak Bomber Air Force never fully materialized due to later political developments and progress in military aviation. The Ilyushin Il-28 was therefore the first, the only and the last jet bomber in the history of the Czechoslovak and Czech Air Force. Its eighteen years of active service in the Czechoslovak People's Army can be seen as fully-fledged and successful, based on the number of hours flown (thousands of hours) and completed tasks (hundreds of flight tasks) in relation to serious occurrences (disasters, accidents and damage events) and deaths of the crew.

In terms of fire safety of the aircraft and its crew, the aircraft was equipped with a fire-fighting and inert gas systems that were very sophisticated and functional for its time and clearly reflected the extensive practical experience with aircraft fires in the World War II when the vast majority of Soviet warplanes had no fire protection system at all.

The author would like to express his thanks to and deep appreciation of the Czechoslovak flight and non-flight staff that flew and worked with the Il-28. From the perspective of the current level of technical knowledge and aviation safety concepts, we can say that the operation and maintenance of the Il-28 demanded not only extraordinary courage and technical knowledge, but also accuracy, consistency, concentration and perseverance, for which the staff still deserves our admiration and respect.

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References

- [1] ADAMEC, J. and KOCÁB, J. *Aircraft Engines* (in Czech). 2nd ed. Praha: Nakladatelství Corona spol. s.r.o., 2008, 176 p. ISBN 978-80-86116-54-9.
- [2] *Il-28: Album of basic views, schemes and drawings: design, electrical installation, equipment* (in Russian). 1st ed. LKVVIA, 1951 [Archives of the Military History Institute in Prague – Air Museum Kbely; Ministry of National Defense central registry code: S/Mat let-1-633].
- [3] IRRÁ, M. *Ilyushin Il-28: The Ilyushin Il-28 in the Czechoslovak Air Force* (in Czech). 1st ed. Nevojice: Jakab, 2013, 128 p. ISBN 978-80-87350-12-6.

- [4] IRRA, M. *MiG-15: Vol. 1* (in Czech). 1st ed. Nevojice: Jakab, 2006, 104 p. ISBN 80-903637-4-1.
- [5] IRRA, M. *MiG-15: Vol. 2* (in Czech). 1st ed. Nevojice: Jakab, 2007, 104 p. ISBN 80-903-6377-6.
- [6] IRRA, M. *MiG-15: Vol. 3*. (in Czech). 1st ed. Nevojice: Jakab, 2007, 96 p. ISBN 978-80-87161-01-2.
- [7] *Visual Aids to the Pilot Operation and Piloting Guide of Il-28 and Il-28U* (in Russian). 1st ed. Moscow: USSR Department of Defense Military Publishing, 1972, 292 p.
- [8] *Regulation of the Air Force Commander. 6th April 1955* (in Czech – transcript of the original aircraft flight manual for the Il-28 and its variants in Russian). 1st ed. Praha: Ministry of National Defense, 1955, 92 p. [personal archive of Mr. Jaroslav Janda].
- [9] *Pilot Instructions for Special Cases in Flight for Il-28, Il-28R, Il-28U* (in Czech – transcript of the original documentation in Russian) 1st ed. Přerov: 25th Bomber Regiment, 1958, 39 p. [personal archive of Mr. Jaroslav Janda].
- [10] ŘEZŇÁK, Libor. *The Steel Stallion MiG-19 and the Czechoslovak Air Force 1958–1972* (in Czech). 1st ed. Cheb: Svět křidel, 2008, 582 p. ISBN 978-80-86808-45-1.
- [11] ŘEZŇÁK, L. *The Silver Jet MiG-15: Jet Beginnings of the Czechoslovak Air Force 1950–1957* (in Czech). 1st ed. Cheb: Svět křidel, 2012, 567 p. ISBN 978-80-87567-14-2.
- [12] VELEK, M., PAJER M. and KRUMBACH J. *Illustrated History of Aviation: Ilyushin Il-28, Vickers Wellington, Marcel Bloch MB-200* (in Czech). 1st ed. Praha: Naše vojsko, 1987, 176 p.