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Fire-fighting Systems in Aircraft in the Service of Czechoslovakia and the Czech Republic since 1948

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Abstract:

Fire-fighting equipment is currently a common part of the technical equipment in transport, military and most recreational aircraft. But it was not always so. Aircraft fire protection systems and their historical development represent a very important but neglected chapter in the history of aviation and fire protection. This article provides a brief overview of extant information and technical points of interest that form the basis of today's fire protection systems in combat military aircraft. The article is specifically focused on trends in fire-fighting equipment in jet combat aircraft in the service of the Army of the Czech Republic and former Czechoslovakia since 1948.

Keywords:

Army of the Czech Republic, Czechoslovak Army, Czechoslovak People's Army, halon, carbon dioxide, jet combat aircraft, fire extinguishing equipment, development trend

1. Introduction

Fire is one of the most serious incidents that may occur on board of aircraft. In order to prevent the loss of human lives and to minimize damage to aircraft, various elements to prevent fire from occurrence and spread are now standard aircraft equipment. Fire-fighting equipment is one of these elements.

Aircraft fire-fighting equipment is a set of technical components designed to work together to extinguish a fire arising in a part of aircraft, both on the ground and in the air during flight. At present, such a system usually consists of a fire detector, vessel(s) with a fire-extinguishing agent, distribution tubing, spray nozzles or manifolds, and, as the case may be, additional tubing and fittings.

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Engine units, auxiliary power units, hot air ducts for air conditioning, electronic blocks, brakes and wheel bays are in most cases subject to protection against fire.

If a fire occurs, to extinguish it as quickly as possible is essential in order to avoid endangering the crew and to avoid any change in properties due to intense thermal stress of materials the aircraft is constructed from. This thermal stress to aircraft components during a fire could result in loss of their structural strength and subsequent deformation or even destruction (e.g. wing break-off).

Aircraft fire-extinguishing equipment systems have their own history and development like many other things. However, despite their importance, they tend to be unjustly neglected in scientific and historical literature. This is evidenced by the fact that in professional literature on aviation, only very fragmentary information and incidental mention of these systems are presented. Even flight manuals for pilots of individual types of aircraft are limited to most essential basic instructions on manual or automatic activation of these systems. More detailed information can be found only in internal technical documentation for individual aircraft types, which is very difficult to access. Some of the technical documentation, especially for older aircraft types, cannot be found in archives of public institutions any longer. For these and other reasons, thematic and informational content of the following paragraphs can be considered unique. History has always been, is and will be a source of inspiration, experience and respect to the current level of technological progress, at least in this technical sector.

2. Jet Combat Aircraft in the Service of the ČSA, ČSLA and AČR

The army defending the territory of the former Czechoslovakia and later of the present Czech Republic changed its name several times during its existence. In 1920–1950 it was the Czechoslovak Armed Forces (in Czech: Československá branná moc), in 1950–1954 the Czechoslovak Army (in Czech: Československá armáda; hereinafter "ČSA"), in 1954–1990 the Czechoslovak People's Army (in Czech: Československá lidová armáda; hereinafter "ČSLA"), in 1990–1992 again the Czechoslovak Army, and since 1st January 1993 it has been the Army of the Czech Republic (in Czech: Armáda České republiky; hereinafter "AČR"). Depending on the time period, the air forces of those armies are referred to respectively [1].

In the history of Czech and Czechoslovak jet aviation, there have been a total of sixteen types of jet fighter, bomber, attack, surveillance or trainer aircraft in various variants (see Fig. 1). The first one was the originally German Messerschmitt Me-262 "Schwalbe" jet fighter in Czech variants Avia S-92 and two-seat Avia CS-92, the latest being the Swedish Saab JAS-39 Gripen. In the time between, the Yakovlev Yak-23, Ilyushin Il-28, Mikoyan-Gurevich MiG-15, Mikoyan-Gurevich MiG-17, Mikoyan-Gurevich MiG-19, Mikoyan-Gurevich MiG-21, Mikoyan-Gurevich MiG-23, Mikoyan-Gurevich MiG-29, Sukhoi Su-7, Sukhoi Su-22, Sukhoi Su-25, Aero L-29 Delfin, Aero L-39 Albatros, and Aero L-159 Alca have served in the Czechoslovak or Czech Air Force.

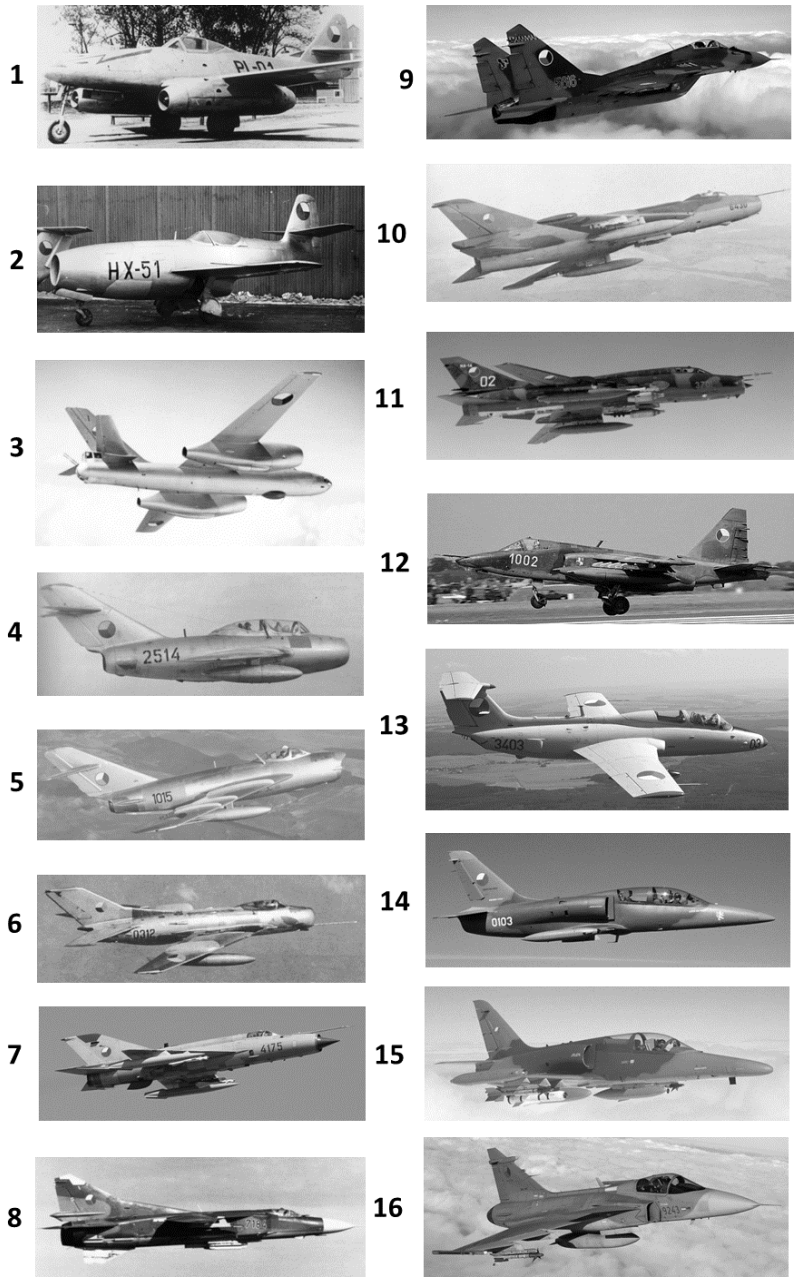

Fig. 1 Complete listing of military jet combat aircraft used since 1948 to protect the airspace of Czechoslovakia or the Czech Republic: (1) Messerschmitt Me-262A's Czechoslovak variant Avia S-92, (2) Yakovlev Yak-23, (3) Ilyushin Il-28U, (4) Mikoyan-Gurevich MiG-15UTI, (5) Mikoyan-Gurevich MiG-17PF, (6) Mikoyan-Gurevich MiG-19S, (7) Mikoyan-Gurevich MiG-21MF, (8) Mikoyan-Gurevich MiG-23MF, (9) Mikoyan-Gurevich MiG-29A, (10) Sukhoi Su-7BKL, (11) Sukhoi Su-22M-4, (12) Sukhoi Su-25K, (13) Aero L-29 Delfin, (14) Aero L-39C Albatros, (15) Aero L-159A Alca, (16) Saab JAS-39C Gripen

2.1. The Messerschmitt Me-262 in the Czechoslovak Air Force

After World War II the Messerschmitt Me-262 "Schwalbe" was reconstructed from remains with documentation left by Germans into the Avia S-92 and Avia CS-92. The Avia S-92 was a single-seat twin-engined jet fighter variant of the original German Messerschmitt Me-262A. The Avia CS-92 was a two-seat jet fighter trainer variant of the original German Messerschmitt Me-262B. The two variants of the aircraft became the first jet fighters to serve in the air forces of the Czechoslovak Armed Forces and later ČSA. They served in 1948–1951. Only twelve aircraft of both variants were built (nine Avia S-92s and three Avia CS-92s) [2], [3].

2.2. The Yakovlev Yak-23 in the Czechoslovak Air Force

The Yakovlev Yak-23 (NATO reporting name "Flora", Czechoslovak code name S-101) was a Soviet-built single-seat single-engined jet fighter aircraft. It operated in the CSA air force in 1951–1956. Only twelve aircraft were delivered. It was soon technically superseded by the incoming Mikoyan-Gurevich MiG-15 (see below) [2]].

2.3. The Ilyushin Il-28 in the Czechoslovak Air Force

The Ilyushin Il-28 (NATO reporting name "Beagle") was a Soviet-built three-seat twin-engined jet bomber and surveillance aircraft. It operated in the ČSLA Air Force in 1955–1973 (in four variants: Il-28, Il-28U, Il-28R, and Il-28RT/Il-28RTR). Until 1956, three variants were denoted as B-228 (the original Il-28), CB-228 (the original Il-28U) and B-228R (the original Il-28R) in former Czechoslovakia [5].

2.4. The Mikoyan-Gurevich MiG-15 in the Czechoslovak Air Force

The Mikoyan-Gurevich MiG-15 (NATO reporting name "Fagot", or "Midget" for the MiG-15UTI variant) was a Soviet-built single or two-seat single-engined jet fighter aircraft. It operated in the ČSA and ČSLA Air Force in 1951–1983 (in ten variants: MiG-15, MiG-15bis, MiG-15 SB, MiG-15bis SB, MiG-15R, MiG-15bis R, MiG-15T, MiG-15bis T, MiG-15UTI, and MiG-15UTI-P). Until 1956, three variants were denoted as S-102 (the original MiG-15), CS-102 (the original MiG-15UTI), and S-103 (the original MiG-15bis) in former Czechoslovakia [2], 7-9].

2.5. The Mikoyan-Gurevich MiG-17 in the Czechoslovak Air Force

The Mikoyan-Gurevich MiG-17 (NATO reporting name "Fresco") was a Soviet-built single-engined jet fighter aircraft (single-seat in the ČSLA Air Force). It operated in the ČSLA Air Force in 1955–1968 (in two variants: MiG-17F and MiG-17PF). Until 1956, it was denoted as S-104. Unlike its predecessor, it was equipped with an afterburner and an airborne radar in former Czechoslovakia [2]

2.6. The Mikoyan-Gurevich MiG-19 in the Czechoslovak Air Force

The Mikoyan-Gurevich MiG-19 (NATO reporting name "Farmer") was a Soviet-built twin-engined jet fighter aircraft (single-seat in the ČSLA Air Force). It operated in the ČSLA Air Force in 1958–1972 (in four variants: MiG-19S, MiG-19P, MiG-19PM, and MiG-19SF). It was the first supersonic jet fighter ever in the service of Czechoslovak armed forces. In former Czechoslovakia, one variant was license-built as Aero S-105 (the original MiG-19S) [2]

2.7. The Mikoyan-Gurevich MiG-21 in the Czechoslovak and Czech Air Force

The Mikoyan-Gurevich MiG-21 (NATO reporting name "Fishbed") was a Soviet-built single or two-seat single-engined jet fighter aircraft. It operated in the ČSLA and AČR Air Forces in 1961–2005 (in ten variants: MiG-21F-13, MiG-21PF, MiG-21PFM, MiG-21R, MiG-21MA, MiG-21MF, MiG-21MFN, MiG-21U, MiG-21US, and MiG-21UM). In former Czechoslovakia, one variant was license-built as Aero S-106 (the original MiG-21F-13). It was the first jet fighter in the service of Czechoslovak armed forces to fly at more than twice the speed of sound [2]

2.8. The Mikoyan-Gurevich MiG-23 in the Czechoslovak and Czech Air Force

The Mikoyan-Gurevich MiG-23 (NATO reporting name "Flogger") was a Soviet-built single or two-seat single-engined jet fighter aircraft. It operated in the ČSLA and AČR Air Force in 1978–1998 (in four variants: MiG-23BN, MiG-23MF, MiG-23ML, and MiG-23U). It was the first variable-geometry jet fighter in the service of Czechoslovak armed forces [2]

2.9. The Mikoyan-Gurevich MiG-29 in the Czechoslovak and Czech Air Force

The Mikoyan-Gurevich MiG-29 (NATO reporting name "Fulcrum") was a Soviet-built single or two-seat twin-engined jet fighter aircraft. It operated in the ČSLA and AČR Air Force in 1989–1994 (in two variants: MiG-29A and MiG-29UB). Twenty aircraft (eighteen single-seat MiG-29As and two two-seat MiG-29UBs) were delivered to former Czechoslovakia; after the dissolution of Czechoslovakia, ten remained in the service of the AČR (nine MiG-29As and one MiG-29UB) [17].

2.10. The Sukhoi Su-7 in the Czechoslovak Air Force

The Sukhoi Su-7 (NATO reporting name "Fitter-A"") was a Soviet-built single or two-seat single-engined jet bomber and attack aircraft. It operated in the ČSLA Air Force in 1964–1990 (in three variants: Su-7BM, Su-7BKL, and Su-7U). The Su-7BM variant was also designed as a nuclear-bomber plane [18].

2.11. The Sukhoi Su-22 in the Czechoslovak and Czech Air Force

The Sukhoi Su-22 (NATO reporting names "Fitter-K" for Su-22M-4 and "Fitter-G" for Su-22UM-3) was a Soviet-built single or two-seat single-engined jet fighter-bomber aircraft with variable-sweep wings. It operated in the ČSLA and AČR Air Force in 1984–2002 (in two variants: Su-22M-4 and Su-22UM-3) [19].

2.12. The Sukhoi Su-25 in the Czechoslovak and Czech Air Force

The Sukhoi Su-25 (NATO reporting name "Frogfoot") was a Soviet-built single or two-seat twin-engined jet attack aircraft designed to provide close air support for the ground forces. It operated in the ČSLA and AČR Air Force in 1984–2000 (in two variants: Su-25K and Su-25UBK). Thirty-eight aircraft (thirty-six single-seat Su-25Ks and two two-seat Su-25UBKs) were delivered to former Czechoslovakia; after the dissolution of Czechoslovakia, twenty-five remained in the service of the AČR (twenty-four Su-25Ks and one Su-25UBK) [20].

2.13. The Aero L-29 Delfin in the Czechoslovak and Czech Air Force

The Aero L-29 Delfin (NATO reporting name "Maya") was a Czechoslovakia-built single or two-seat single-engined subsonic jet trainer and surveillance aircraft. It operated in the ČSLA, ČSA and AČR Air Force in 1963–2003 (in four variants: L-29, L-29A, L-29R, and L-29RS) [2]

2.14. The Aero L-39 Albatros in the Czechoslovak and Czech Air Force

The Aero L-39 Albatros is a Czechoslovakia-built single or two-seat single-engined subsonic jet trainer, fighter and attack aircraft. It has operated in the ČSLA and AČR Air Force since 1971 (in six variants: L-39C, L-39V, L-39ZO, L-39ZA, L-39Z/ART, and L-39MS) [2]

2.15. The Aero L-159 Alca in the Czech Air Force

The Aero L-159 Alca is a Czech-built single or two-seat single-engined subsonic jet trainer, fighter and attack aircraft. It has operated in the AČR Air Force since 1999 (in three variants: L-159A, L-159T1, and L-159B) [23]

2.16. The Saab JAS-39 Gripen in the Czech Air Force

The Saab JAS-39 Gripen is a Sweden-built single or two-seat single-engined supersonic jet fighter, attack and surveillance aircraft. It has operated in the AČR Air Force since 2005 (in two variants: JAS-39C and JAS-39D) [25]

3. Fire-fighting Equipment in ČSA, ČSLA and AČR Jet Combat Aircraft

It is an interesting fact that the first two jet fighters in Czechoslovak armed forces, Messerschmitt Me-262 "Schwalbe" (i.e., Czechoslovak variants Avia S-92 and Avia CS-92) and Yakovlev Yak-23 (Czechoslovak code name S-101), had no fire-fighting equipment or other active fire-fighting elements. With regard to the risk of fire, flying these aircraft must have been very dangerous. All subsequent types of aircraft were equipped with some kind of fire-fighting equipment [4]

3.1. Ilyushin Il-28 Fire-fighting System

The Ilyushin Il-28 was equipped with a fire-fighting system consisting of two main segments: an engine protection segment and a fuel tanks protection segment.

The engine protection segment consisted of two eight-litre (5.7 kg) fire extinguishant pressure bottles with carbon dioxide located on the right side of the fuselage, 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 in the cockpit by two red warning lights. 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.

The fuel tanks protection segment consisted of one eight-litre (5.7 kg) fire extinguishant pressure bottle with carbon dioxide located in the fuselage, 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. It was a system of fire and explosion prevention in case the fuel tanks would have got hit during combat [5]

3.2. Mikoyan-Gurevich MiG-15 Fire-fighting System

The Mikoyan-Gurevich MiG-15 was equipped with a fire-fighting system consisting of four bimetallic membranes (fire detectors) to evaluate the static reaction temperature range of 140–160 °C in the engine compartment at the rear of the combustion chambers and near the turbines, two three-litre (2.2 kg) fire extinguishant pressure bottles with liquid carbon dioxide, tube spray manifolds, and additional tubing and fittings (see Fig. *2*). Detection of a fire was indicated by lighting up a warning light panel in the cockpit, upon which the pilot manually activated the fire-extinguishing equipment [7]

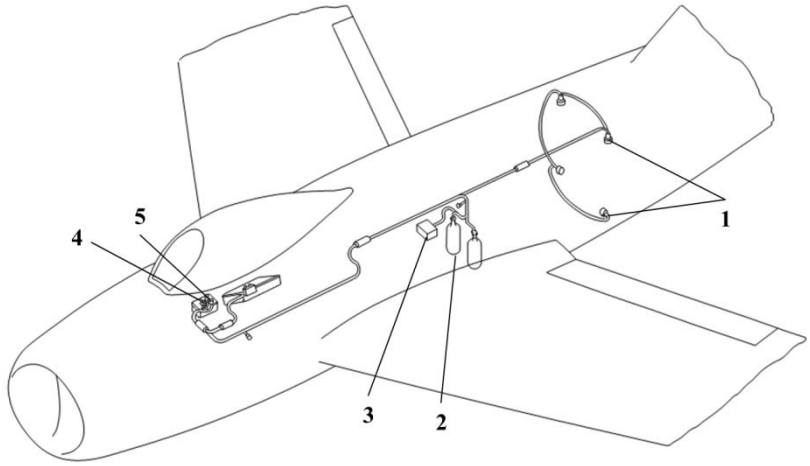

Fig. 2 Mikoyan-Gurevich MiG-15 fire-fighting system [29]: (1) bimetallic membranes–fire detectors, (2) fire bottle with extinguishing agent, (3) fire valve, (4) signal lamp in the cockpit, (5) fire extinguishing system activation pressbutton

3.3. Mikoyan-Gurevich MiG-17 Fire-fighting System

The Mikoyan-Gurevich MiG-17 was equipped with a fire-fighting system consisting of four bimetallic membranes (fire detectors) to evaluate the static reaction temperature range of 180±20 ºC in the engine compartment at the rear of the combustion chambers and near the turbines, two three-litre (2.2 kg) fire extinguishant pressure bottles with liquid carbon dioxide, tube spray manifolds, and additional tubing and fittings. Detection of a fire was indicated by lighting up a warning light panel in the cockpit, upon which the pilot manually activated the fire-extinguishing equipment. The system was identical to that in the Mikoyan-Gurevich MiG-15 with different calibrations of heat detectors [10].

3.4. Mikoyan-Gurevich MiG-19 Fire-fighting System

The Mikoyan-Gurevich MiG-19 was equipped with a fire-fighting system consisting of three bimetallic membranes (fire detectors) to evaluate the static reaction temperature range of 200+50 ºC, one three-litre (2.2 kg) fire extinguishant pressure bottle with liquid carbon dioxide extinguishing agent, tube spray manifolds, and additional tubing and fittings. Detection of a fire was indicated by lighting up a warning light panel in the cockpit, upon which the pilot manually activated the fire-extinguishing equipment. The system was identical to those in Mikoyan-Gurevich MiG-15 and MiG-17 with different calibrations of temperature detectors. It is an interesting fact that the first variant of the aircraft, the MiG-19S, was not equipped with any fire-extinguishing equipment. It only was equipped with an alarm system to indicate fire in the engine compartment. If a fire was detected during the flight, the pilot had to eject [11]

3.5. Mikoyan-Gurevich MiG-21 Fire-fighting System

The Mikoyan-Gurevich MiG-21 was equipped with a fire-fighting system consisting of an ionization flame detector in the engine compartment, one two-litre fire extinguishant pressure bottle with a mixture of anhydrous carbon dioxide, bromomethane and bromoethane (known as "Mixture 7"), two steel tube spray manifolds located at the engine rims, and additional elements, tubing and fittings (see Fig. 3). Detection of a fire was indicated by lighting up a warning light panel in the cockpit, upon which the pilot manually activated the fire-extinguishing equipment [14]

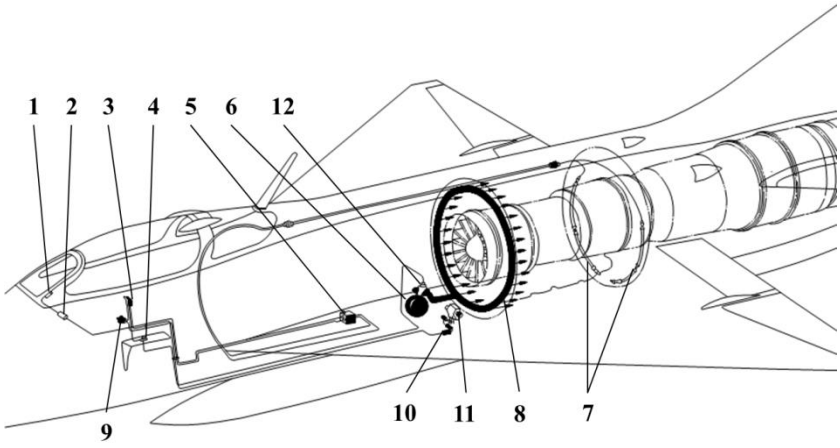

Fig. 3 Mikoyan-Gurevich MiG-21 fire-fighting system [33]: (1) signal lamp, (2) lamp monitoring relay, (3) automatic network guard, (4) fire extinction button, (5) valve amplifier, (6) fire bottle with extinguishing agent, (7) ionization flame detectors, (8) circular spray manifold, (9) shut-off cock button, (10) valve, (11) shut-off cock, (12) pyrocartridge

3.6. Mikoyan-Gurevich MiG-23 Fire-fighting System

The Mikoyan-Gurevich MiG-23 was equipped with a fire-fighting system consisting of two linear heat detectors in the engine compartment, one three-litre fire extinguishant pressure bottle with air-propelled FREON $114V_2$, two spray collectors, and additional elements, tubing and fittings. Detection of a fire was indicated by an acoustic signal and

by lighting up a warning light panel in the cockpit, upon which the pilot manually activated the fire-extinguishing equipment [16]

3.7. Mikoyan-Gurevich MiG-29 Fire-fighting System

The Mikoyan-Gurevich MiG-29 was equipped with a fire-fighting system consisting of ionization flame detectors placed in engine nacelles and near the gearbox, one 2.7–3 l fire extinguishant pressure bottle with air-propelled FREON $114V_2$ (or newer FE 36), spray manifolds, and additional elements, tubing and fittings. Detection of a fire was indicated within 3 seconds by an acoustic signal and by lighting up a warning light panel in the cockpit, upon which the pilot manually activated the fire-extinguishing equipment specifically for the left or right engine, or gearbox. The pilot had to choose the fire extinction target area correctly because the extinguishing equipment could only be used once [17].

3.8. Sukhoi Su-7 Fire-fighting System

The Sukhoi Su-7 was equipped with a fire-fighting system consisting of three main segments: a fire prevention segment, fire warning segment, and fire extinction segment.

The fire prevention segment consisted of titanium cast iron fire barrier separating the engine compartment from the aft fuselage where the engine section most prone to ignite was located and a special engine cooling air jacket placed on the engine and what was called an "extension tube". The cover protecting the fuselage against overheating formed with the surface of the engine and the extension tube an annular slit. In flight, the air continuously flowed through the slit and cooled the tube walls.

The fire warning segment consisted of six fire detectors connected in two series in the engine compartment and in the aft fuselage. Detection of a fire was indicated by lighting up (a) warning light panel(s) in the cockpit(s), upon which the pilot(s) manually activated the fire-extinguishing equipment.

The fire extinction segment consisted of a storage tube (not a pressure bottle) with 5 kilograms of "Mixture 7" extinguishing agent (see above), a special two-litre tank with compressed air for spraying the extinguishing agent, two circular spray manifolds, and additional elements, tubing and fittings. Simultaneously with the activation of the fire-extinguishing equipment, the doors in engine cooling air ducts closed to interrupt the engine air blowing, which was supposed to increase the fire extinguishing efficiency. After the fire was extinguished, the engine unit was not allowed to re-run and, as a general rule, the pilot had to eject [36]

3.9. Sukhoi Su-22 Fire-fighting System

The Sukhoi Su-22 was equipped with a fire-fighting system consisting of an ionization flame detector in the engine compartment, one four-litre fire extinguishant pressure bottle with nitrogen gas-propelled CHLADON $114V_2$, three titanium spray manifolds, and additional elements, tubing and fittings. Detection of a fire was indicated by flashing a backlit warning light panel and an acoustic signal in the cockpit, upon which the pilot manually activated the fire-extinguishing equipment. In addition to the engine compartment, the tail section of the fuselage, fuel tanks in the fuselage and fuel tanks in the wings were also equipped with fire safety features. There was a "high temperature protective casing" installed around the engine unit. Cooling air was delivered to the space between the engine and the casing. From two sixteen-litre cylinders placed in the fixed part of the wings, nitrogen gas under the pressure of 120÷240 kPa was fed into the

fuel tanks in the wings and the fuselage above the fuel surface. Ventral tanks had no such safety feature. The fire extinction system was one-off [19]

3.10. Sukhoi Su-25 Fire-fighting System

The Sukhoi Su-25 was equipped with a fire-fighting system consisting of twelve heat detectors (with thermocouple sensors) in each of the two engine sections, two four-litre fire extinguishant pressure bottles containing mixture of 5.64 kg of FREON $114V_2$ and air, two steel spray manifolds placed in the engine compartments, and additional elements, tubing and fittings. Each fire bottle was equipped with two 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 in the cockpit by two red warning lights separate for right and left engine. 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 (the warning signal continued), the pilot manually activated the second fire bottle with the extinguishing agent. After the fire was extinguished, the engine unit was not allowed to re-run. It was possible to land safely even with one functional engine. If extinguishing the fire was unsuccessful, the crew had to eject [20]

3.11. Aero L-29 Delfin Fire-fighting System

The Aero L-29 Delfin was equipped with a fire-fighting system consisting of four heat (thermal differential) detectors to evaluate the static reaction temperature range of 130±30 ºC in the engine compartment at the rear of the combustion chambers, one three-litre (2.2 kg) fire extinguishant pressure bottle with liquid carbon dioxide, tube spray manifolds, wiring, and additional elements, tubing and fittings. Detection of a fire was indicated on a backlit warning light panel and by an acoustic signal in both cockpits, upon which either pilot could manually activate the fire-extinguishing equipment [46]

3.12. Aero L-39 Albatros Fire-fighting System

The Aero L-39 Albatros is equipped with a fire-fighting system consisting of six heat (thermal differential) detectors split into two series responding to rapid increase in temperature in the engine compartment, one two-litre fire extinguishant pressure bottle with Halon 2402, tube spray collectors, wiring, and additional elements, tubing and fittings (see *Fig. 4)*. Detection of a fire is indicated on a backlit warning light panel and by an acoustic signal in both cockpits, upon which either pilot can manually activate the fire-extinguishing equipment [22, 48, 49, 50].

3.13. Aero L-159 Alca Fire-fighting System

The Aero L-159 Alca aircraft is equipped with a fire-fighting system consisting of three linear heat detectors (responding to the rise in temperature in the engine compartment) placed around the auxiliary power unit and hydraulic filters, one two-litre fire extinguishant pressure bottle with Halon 1301, tube spray manifolds, and additional elements, tubing and fittings. Detection of a fire is indicated on a backlit warning light panel and by an acoustic signal in both cockpits, upon which either pilot can manually activates the fire-extinguishing equipment [23].

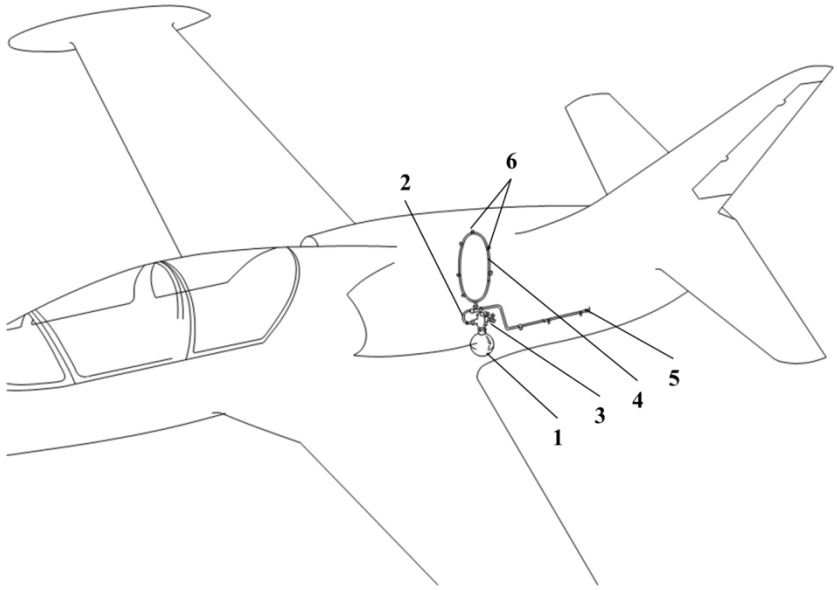

Fig. 4 Aero L-39 Albatros fire-fighting system [50]: (1) fire bottle with extinguishing agent, (2) feed tubing, (3) closure body, (4) circular spray manifolds, (5) bar spray manifold, (6) attachment to the fuselage bulkhead

3.14. Saab JAS-39 Gripen Fire-fighting System

The Saab JAS-39 Gripen is equipped with a fire-fighting system consisting of a line-type pneumatic linear heat detector (preset to respond if detector temperature exceeds 200 °C or local temperature exceeds 540 °C) located in the engine and auxiliary power unit compartments, one fire extinguishant pressure bottle with 0.45 kg of Halon 1301 and nitrogen gas expellant (only for extinguishing the auxiliary power unit fire), tube spray manifolds and additional elements, tubing and fittings. Detection of a fire is indicated on a backlit warning light panel and by an acoustic signal in the cockpit. As for the auxiliary power unit fire, the extinguishing starts automatically within 10 seconds after the alarm is activated. If an engine fire occurs on the ground or during flight, "engine cold run-up" ("motoring") procedure is used. In this procedure, the pilot shuts off the engine and spins it with fuel shut-off valve closed (no fuel flow to the engine unit). If extinguishing the fire is successful, the engine can be re-run at full fuel-flow. In flight, sufficient altitude and airspeed is necessary to perform the procedure to avoid crashing the aircraft. If fire persists, the pilot has to eject [25]. More detailed information on fire protection systems in aircraft serving the AČR are part of the military secret, so the authors decided not to include them in this study.

4. Development Trends

From the above mentioned list of facts and other information obtained by research on the topic, development trends in fire-fighting systems in ČSA, ČSLA and AČR jet fighters over the past almost seventy years can be defined as follows:

(a) Fire detection response time and reliability has increased.
(b) The efficiency of fire-fighting in aircraft has increased due to more efficient extinguishing agents (carbon dioxide was abandoned in favor of halon and freon extinguishing agents).
(c) The quantity of extinguishing agents has decreased due to their better extinguishing capability.
(d) The weight of the fire-fighting system decreased due to the choice of more appropriate extinguishing agents and their optimized distribution into protected parts of the aircraft.
(e) The fire resistance of materials used for fire seals, fire barriers has increased.
(f) Procedures and operations of pilots in the event of a fire have simplified, up to full automation.
(g) Pyromechanical activation of fire-extinguishing equipment was abandoned in favour of pyrotechnical activation.
(h) Safety and reliability of pyrocartridges triggering the fire-extinguishing equipment has increased.
(i) The technical documentation, and maintenance and operational records management has improved.
(j) In contrast to earlier times, the purpose of fire-fighting systems is to protect not only the pilot's life, but also the aircraft itself.

5. Conclusion

Aviation history and historical development of the view of safety and fire protection in aviation have changed significantly over the past seventy years. Looking back over generations of pilots, mechanics, aircraft engineers and all other aviation personnel who fought for freedom and sovereignty of their countries during the World War II and the first few decades after it, we must respect them and hold them in esteem.

Thanks to their courage, intelligence, determination, love for flying and their experience, safety and fire protection in aviation has grown to its present form. The history and development of fire protection systems in aviation certainly should not be ignored as they help us understand many principles and rules that contribute to the ever increasing flight safety. Let's honor and respect all those who have contributed to today's level of fire safety in aviation.

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