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MEANS OF TRANSPORT AND DISTRIBUTION SYSTEM OF AVIATION FUELS IN STATE AVIATION

Summary. The provision of quality fuels to the aircraft requires compliance with a number of procedures during the transport, storage and distribution processes. Depending on the needs and organisational conditions, the air fuel distribution process is carried out using various types of transport means. The operational procedures and specificity of the functioning of the Armed Forces and other public law enforcement entities require the use of various construction and technological solutions allowing the efficient functioning of state aviation. The means of transport should not only ensure the appropriate quality of aviation fuel delivered to the aircraft but also enables the delivery of appropriate fuel practically to any place where it is required by the specific activities of particular services or aviation types units of the Armed Forces. This paper presents specific types of transport and distribution means used in state aviation and attempts to select features that determine their suitability for particular types of state aviation.

Keywords: state aviation, aviation fuels, distribution, means of transport.

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1. Introduction

Issues with supplying the proper quality of aviation fuel to the aircraft tank are as old as the construction of aircraft equipped with internal combustion engines. Requirements in relation to fuel quality increased with the development of aircraft engine structures. Along with the quality requirements, the requirements related to the method of delivering fuel to the aircraft, its quantity and efficiency of distribution devices also improved. Technological development of crude oil processing made it possible to meet the expectations of aircraft engine manufacturers in the matter of aviation fuel quality. However, despite the technological progress in the domain of fuel infrastructure and transport equipment, the main problem remains the provision of appropriate, high-quality fuel to the aircraft fuel tank. This is particularly important in the case of state aviation², where the filling of an aircraft container can be carried out at an airport without proper fuel supply infrastructure. Such a situation occurs in the case of state aviation, especially as applies to cases of helicopters of the Armed Forces, the Police and the Border Guard. At present, the State Fire Service does not have aircraft. In specific cases, it is supported by the Police aircraft, the Polish Medical Air Rescue and private aircraft. The state aviation supply system is very diverse depending on the type of state aviation.

The most developed system of supplying aviation fuel is the Armed Forces that have the largest air fleet. The Armed Forces have its own fuel infrastructure together with storage containers and means of transport for transporting and distributing fuel to aircraft. Moreover, the Armed Forces have the most diversified transport equipment in terms of its technical design and functionality. Whereas, the Police and the Border Guard aviation initially used transport equipment taken over from the army. However, the poor technical condition of this equipment and relatively obsolete constructions have resulted in a complete replacement of owned transport equipment and aviation fuel distribution process to aircraft.

2. Requirements for transport means

The main requirement for transport means for the conveyance and distribution of aviation fuel is to ensure the quality of the transported fuel. The fuel quality must be adequate in terms of physicochemical and operational properties. It is the main element determining the construction, functionality and applied technology of the equipment. However, such factors as the possibility of delivering the right amount of fuel to the tank of the aircraft at a strictly defined time and place should also be taken into account. These properties take on particular significance, especially in the case of the need to refuel in small airports, airstrips or temporary created landing sites. Most of the aircraft, especially the ones belonging to the Police and the Border Guard, have the ability to operate from such places. They can be used during operational, patrol, crisis or rescue operations during natural disasters. Fuel requirements for particular types of Border Guards and Police aircraft are shown in Table 1.

² The state aviation includes aircraft, the Armed Forces crews, Border Guard, State Fire Service and Police, and airports used exclusively by state aircraft

Tab. 1

Selected technical parameters of Police and Border Guard aircraft

Aircraft type	Capacity of the main fuel tank / with an additional one (l)	Cruising speed (km/h)	Range (km)
Mi-8	1.870 / 2.615	250	350 / 540
W-3	1.700	235	690
Mi-2	1070	160	540
Bell-412B-HP	1.246	222	650
Bell-206B-III Jet Ranger	345	190	550
PZL-104MF Wilga 2000	400	208	1.240
M 20 Mewa	465	311	1.240
PZL M28B	1.960	365	1.400
PZL Kania	600 / 1.023	190	435 / 886
W-3AM Anakonda	1.700	235	734

To accomplish the above tasks, helicopters are most often assigned to carry out tasks from small airports or landing areas without a constructed runway. Reaching these landing sites, especially in crisis situations or natural disasters conditions, will require transport equipment with adequate capabilities to navigate on dirt roads or off-road. This feature is referred to as high operational mobility. This type of vehicle has an all-axle drive, suitable for wading (overcoming shallow-water obstacles). Vehicles will move along paved roads in order to reach the aircraft, however, at the stage of refuelling the tanker should drive as close as possible. Often there have been cases of serious difficulties in moving tankers near helicopters. Tankers distributors are usually equipped with delivery hoses with maximum length of 20 m and the tanker must be located at a distance of maximum 18 m from the helicopter to efficiently fill the helicopter tank with fuel. In practice, these are smaller distances, which forces the tanker to enter the school playground, meadow or other terrain allowing safe helicopter landing. [3] Only vehicles with off-road chassis will be able to safely reach the aircraft. It also limits the transport possibilities of the vehicle. Most often, these are 4x4 or 6x6 vehicles with main tank capacity for aviation fuel up to 7,500 litres.



Fig. 1. Tanker distributor equipped with a MAN 4x4 chassis, with a capacity of 7,500 l (CSDL-7) for the transport and distribution of aviation fuel, operated by the Border Guard

The vehicle must meet the requirements set out in the Road Traffic Law, ADR requirements for the relevant group of hazardous materials. In the case of tanker distributors used for transportation of aviation fuel, it must meet the requirements for materials designated as UN No. 1863 class 3, classification code F1, packing group III and identification number 30. In addition to technical and operational requirements for transport means, such a vehicle, practically its body, must ensure the possibility of storage and distribution of transported aviation fuel so that it meets the quality requirements specified in API 1581 Edition 5. These tankers have filters or monitors (monitoring filter) compliant with the API requirements that ensure proper purity and anhydridity of the fuel supplied to the aircraft.

Tab. 2

Selected technical parameters of distributors' tanks operated by the Border Guard and the Police

No.	Equipment type	Capacity (l)	Capacity (kg)	Performance (l / min.)	Number of delivery hoses.
1.	CSDL – 7	7.500	6.000	200	1 dispensing unit
2.	CD – 9	8.900	7.120	200	1 dispensing unit
3.	CT-18	18.000	14.400	200	1 dispensing unit



Fig. 2. An 18,000-litre transport tanker (CT-18) with the possibility of distributing aviation fuel to aircraft on a 6x2 MAN chassis operated by the Border Guard

It is also extremely important, due to the quality of fuel and the safety of flights that the structures of elements in contact with the aviation fuel are not made of metals or their alloys, which may react with the fuel. The use of copper, copper alloys, light metals and their alloys containing more than 4% such as copper, zinc, cadmium and lead is highly prohibited [1].



Fig. 3. Tanker distributor with a capacity of 8.900 l (CD-9) for the transport and distribution of aviation fuel on a RENAULT 4x2 chassis operated by the Police

Stationary distribution devices are used in addition to tanker distributors in larger airport facilities (Border Guard or Police landing field). These devices enable the storage of larger amounts of fuel, supplemented with necessary operational additives (additive to prevent water crystallisation) and the fuel supply to the aircraft tank. Moreover, these devices are also equipped with the necessary filters or monitors, which guarantee high fuel quality.



Fig. 4. Border Guard landing area - an aircraft refuelling station with a capacity of 30,000 l, equipped with a distribution node

Both transport and stationary equipment do not necessarily need to have large capacities. Mostly, the Police or the Border Guard do not have a large aircraft fleet - there are usually single pieces. These aircraft do not require significant amounts of fuel at once. The maximum fuel load for large helicopters are about 1,000 litres. In the case of the Mi-8 helicopter or the PZL M28B, this amount may increase to 1,350 litres of aviation fuel.

A significantly different situation occurs in the case of the Armed Forces aviation where the need for specific aviation equipment corresponds to the diversification of aviation military infrastructure, in terms of both facilities location and the size of fuel needs. Mainly in the case of helicopters, there is the need to have tanker distributors mounted on off-road or field-guided chassis. In the field conditions, the specifics of military helicopters' operations necessitates the process of refuelling to be carried out in a rapid way. The tanker should have

the ability to withdraw to hide immediately after the completion of refuelling. Currently, only two types of tanker distributors meet these conditions. The first type is an old construction from the late 70s of the last century, built on a 6x6 off-road car, the Star 266. Its structure allows it to overcome water obstacles with a depth of up to 1.2 m, after preparation up to 1.8 m. This tanker has a 4,500 l capacity and a distribution node that enable aircraft refuelling.



Fig. 5 Tanker distributor with a capacity of 4,500 l (CD-5) for the transportation and distribution of aviation fuel on the STAR 266 chassis, operated by the Armed Forces

The second type of the distributor tanker is a modern design from 2007-2010 and it is built on the Jelcz 662 car chassis with 6x6 drive. This vehicle was initially produced for the army and was intended for land operations, but was subsequently redesigned for air units. This vehicle construction is adapted to operate both on paved roads and on off-road routes and has the ability to overcome water obstacles with a depth of up to 1.2 m.



Fig. 6 Tanker distributor with a capacity of 10,300 l (CD-10) for the transport and distribution of aviation fuel on the JELCZ 662 chassis operated by the Armed Forces

In the Armed Forces, only these two types of vehicles allow aviation fuel transport and distribution to aircraft, in field conditions without the necessity of using paved roads. Of course, practically all military aircraft require a properly prepared runway, taxiways and aprons. However, air operations are planned to be carried out from airports or grass airfields in case of emergency or combat operations. Such operations are practised on transport aircraft such as the CASA C-295 M and the C-130E Hercules.

Access to aircraft for refuelling on a grassy plane can be a major problem for vehicles with road chassis. A similar situation will occur in the event of the need to refuel helicopters, which do not require large areas to take off and land, especially in combat conditions, where they will operate from temporary landing sites. Then it will be necessary to have vehicles with high mobility in off-road conditions with the possibility of delivering the right amount of high-quality aviation fuel to the aircraft at a strictly specified time.[5] It should be emphasised at this point that in the majority of airborne units the basic distribution equipment are road vehicles. In airborne units, the share of new generation tanker distributor constructed on off-road chassis is unsatisfactory. A large number of the distributor tanks currently in use are high capacity vehicles of 20,000 l. At the end of the last century, CD-5 distributors and CD-7,5A distributor tanks on Jelcz 315 road chassis and the upgraded version CD-7.5B on the chassis Road Jelcz 325M were commonly used. A newer version is still quite popular in airborne units, however, it is being phased out of service due to significant wear of mechanical components (gearbox, pump drive for fuel distribution).

Tab. 3

Selected technical parameters of tanker distributors used in the Armed Forces

Equipment type	Capacity (l)	Capacity (kg)	Performance (l / min.)	Number of delivery hoses (dispensing unit)
CD-5	4.500	3.600	350	1 or 2
CD-7,5 B	7.500	6.000	350	1
CD-10	10.300	8.240	200 / 400	1 or 2
CND-21	21.000	16.800	350 / 500	1 or 2
CND-27	27.000	21.600	350 / 500	1 or 2
CND-33	33.000*	26.400*	350 / 500	1 or 2
CN-33	31.300	25.040	Transport type tanker	–
Trailer CP-4	4.000	3.200	Transport type tanker	–
Trailer CP-11	11.000	8.800	Transport type tanker	–

* The tanker can be fully filled up of its maximum capacity only when moving around the airport due to risk of exceeding the permissible total weight of the vehicle specified in the traffic regulations. The maximum amount of fuel is 25,000 l (20,000 kg)

Table 3 presents transport and distribution possibilities of fuel tank distributors currently used by the Armed Forces. Trailers presented in the above Table 3 are an additional container to the capacity of tanker distributors (single vehicles). The CP-4 tanker is intended for the CD-5 tank, while the CP-11 is a reinforcement of the CD-10 tanker. Such a combination of tanker distributor and trailer (set) are used when it is necessary to provide more fuel than

single tanker distributor can provide in a limited time. However, this variant is rarely used due to the rather inconvenient operation of connecting the distributor tank with the trailer and then disconnecting it, which usually results in fuel residues leaking from the connecting hose. Moreover, for safety reasons, such a combined set moves at a limited speed.

Transport and distribution sets (tractor + semi-trailer tanker) CND-27 and CND-33 are much more convenient and more functional to use. The previous version of the transport and distribution set is the CND-21 set. A CND-21 set does not have a good reputation among the operating staff as it creates many difficulties during operation, with the increased risk of failure and extremely difficult when manoeuvring and while driving, especially when there is a small amount of fuel in the tank. This set has been withdrawn from production and the remaining units in use are systematically taken out of service.

The CND-27 set gets the highest marks among the staff servicing the tankers. The construction solutions used enables full advantage of the tanker's container capacity as well as the transport capabilities of the set during its operation at the airport and on public roads. On the other hand, the CND-33 tanker due to the significant own mass of the set needs to adjust the amount of transported fuel while driving on public roads due to the limitations of the permissible gross weight of this type of set, which cannot exceed 40 tons.

The latest model of the tanker is the CN-33 transport type tanker intended for delivery of aviation fuel from the local fuel depots or directly from the producer to the airborne unit. The tanker does not have a distribution node with filter elements that meet the requirements of API 1581 Edition 5.

3. Summary

In recent years, there has been an intense process of exchanging transport equipment in all formations included in the state aviation. Depending on the needs and financial possibilities, this process is in the final phase, or as it happens in the Armed Forces, it will last for many years. It is a continuous process of the gradual withdrawal of old equipment (aged or technically worn) that may be obsolete due to technological changes, hence, does not meet the current requirements. One should not forget about the degradation of vehicles as a result of the operating time [4,6]. The replacement of aviation equipment planned in the coming years in the Police and the Armed Forces is likely to accelerate this process. The transport and distribution possibilities of the equipment currently in use, which is presented in this paper draw the conclusion that the next equipment purchased for the needs of these formations should meet increasingly higher requirements, both technical and operational. It can be concluded that the requirements for fuel distribution equipment used at civilian airports cannot be easily transferred to state airborne units such as the Armed Forces or the Border Guard. An example is the partial use of the available maximum capacity of the tanker distributor CND-33, when transporting fuel on public roads. Doing so may result in the excessive waving of the fuel in the tank during transport, which may even lead to the overturning of the tanker. One of the possible solutions, in this case, would be to reduce the vehicle's own weight in favour of a larger amount of transported fuel. This can be accomplished by replacing the FSC-1500 separator (separation filter) with a suitable monitor that provides the necessary purity of the distributed fuel with less weight and overall vehicle dimensions[2].

Such modification will result in a number of facilities:

- easier access to individual elements of the distribution node

- the possibility of using a lighter load-bearing structure
- reduction of the amount of residual fuel remaining in the junction wires
- a simpler and less onerous way to replace the filter with a new one
- limitation of the filter's replacement execution time
- significant reduction of the amount of fuel that is transferred to waste during servicing

The above changes could also be introduced in the CND-27 tanker to improve its functionality and reliability. It should also be stated that with the current climate changes, the transport or aircraft refuelling on landing sites, especially at airports without proper driver's cabin equipment - tankers operators is a serious mistake in view of safety at work, as it reduces the psychophysical abilities of the driver-operator.

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