EMERGENCY PARACHUTE EQUIPMENT IN GENERAL AVIATION

Pavel JURÍČEK*, Peter KAĽAVSKÝ
Department of Flight Training, Technical University in Košice, Faculty of Aeronautics, Rampová 7, 041 21 Košice, SR
**Corresponding author*. E-mail: pavel.juricek.ml@gmail.com

Summary. This work deals with emergency parachute systems used in general aviation. It gives a description of selected rescue ballistic parachute systems, personal emergency parachutes as well as emergency escape systems. The described systems are produced by a Czech production (the rescue ballistic parachute system and the personal emergency parachute) and of Russian production (the emergency escape system). Besides the description of the rescue ballistic parachute systems the work also gives examples of their use, their location in the aircraft, types of these systems, description of pre-flight operations relating to the rescue system, description of activities relating to the activation of the system, process of ejection, forces acting on the crew during deployment, service life, maintenance and warranty. In the case of personal emergency parachutes the process of the opening of the canopy, technical specifications, warranty and service life have been described. Description of the emergency ejection system includes its operation, its variations as well as its operational parameters. The work further discusses selected aircraft accidents in connection with the use of emergency parachute equipment or omitted use of such equipment. The aim of this work based on accident analysis was to show examples when emergency rescue system could have been used but was not due to its absence or due to the pilot not being equipped with a rescue system. Furthermore it gives examples where either of the above mentioned rescue systems were used. The aim of this work was to give a detailed description of the emergency parachute systems and to specify typical aircraft accidents in connection with the use or omitted use of such equipment as well as comparing rescue ballistic escape systems, personal emergency parachutes and emergency escape systems and point out its advantages and drawbacks. The work also deals with legislation, standard orders and standard requirements concerning parachutes.

Keywords: emergency parachute equipment, personal emergency parachute, emergency escape system, accident

1. INTRODUCTION

Nowadays, in general aviation, there are many types of aircrafts flown by pilots whose skill levels to fly them also vary. It goes without saying, that before starting their service, pilots, the same way as the aircrafts, have to meet certain criteria dictated by the legislation. However; there are many factors that can cause a crisis during a flight - a technical problem with the aircraft, adverse wind conditions, failure to control the aircraft, or the pilot's irresponsibility. All these factors can lead to an emergency during a flight that could have fatal consequences for the aircraft as well and the crew. For this reason, emergency parachutes are manufactured. They can be used by the crew for their own rescue in cases when they are not able to solve the occurring problem in any other way.
The first part of the paper is dedicated to the description of rescue ballistic parachute systems, personal emergency parachutes and emergency escape systems. It contains application examples, version types, system types, their location in the aircraft, pre-flight operations related to rescue systems, operations related to their use during crisis, their actual activation as well as warranty and service life information. The paper describes the ballistic rescue parachute system product lines Magnum supplied

by Stratos 07 s.r.o, and GRS manufactured by Galaxy Holding s.r.o. Personal rescue parachutes described are of the ATL line manufactured by MarS a.s. with the description discussing four types of such parachutes with focus on their technical specification, warranty and service life, and the procedure of opening the parachute. Another system type discussed in the paper is the aforementioned emergency ballistic system type CKC-94 Emergency Escape system from a Russian manufacturer. The next section of the document deals with aviation accidents in connection with the use or omitted use of rescue parachute systems. This section is divided into three subsections, namely: aviation accidents with use of personal emergency parachute; aviation accidents with use of rescue ballistic parachute system; aviation accident without the use of either of these two systems.
In these accident examples can be found the ones caused by an aircraft going to a tailspin either intentionally or unintentionally. Also they mention accidents caused by a technical fault or by a mid-air collision of two aircrafts. The last part of the paper analyses the legislation issue and contains a comparison of some parameters of emergency parachute systems, personal emergency parachutes and rescue ballistic systems listing their advantages and disadvantages.

2. RESCUE PARACHUTE SYSTEM MAGNUM

Rescue parachute system Magnum is a product manufactured by a Czech company Stratos 07 s.r.o. The activation of the system is secured by the use of a rocket engine. *„Rescue parachute systems Magnum are determined for 1 – 2 seat hang-gliders, powered paragliding, ultralight aircrafts, ultralight glider, experimental class and S LSA. The product has been certified by LAA ČR, in USA, DULV and DAEC Germany, by Ssec French association UL and complies with the conditions for purchase of rocket systems.“[1][1]* For the extraction of the canopy, special rocket engines are used. The extraction takes 0,6 to 1,2 s depending on the type of the rocket engine and the temperature of the surroundings at the time of its use. *„After the activation handle is pulled, the movement is mechanically transposed to an ignition device, which activates two igniters in the rocket combustion chamber. Through combustion, gases expand, and escape under high pressure from the combustion chamber through a nozzle which propels the rocket out of the aircraft. The rocket deflects specially designed aircraft cover. The rocket has a sharp tip enabling it to break through a specially designed softer cover materials. As the rocket is propelled, it pulls a cable which opens the parachute container. The parachute hidden in the parachute sleeve is briskly pulled out and away of the aircraft with its connecting chord by the rocket. The parachute sleeve slides back from the canopy in the direction of the apex vent, ensuring the canopy is smoothly and symmetrically loaded.“[1][1]* Magnum contains parachutes which are designed to fully open and fill in the shortest possible time but with increased damping during the canopy deployment. Models designed for use at higher speed open at a slower speed thus preventing the sudden decrease of speed of the aircraft and achieving the smallest possible overload.

3. EMERGENCY PARACHUTE SYSTEMS GRS

Another producer of rescue ballistic parachute systems is Galaxy Holding s.r.o. in Liberec, Czech Republic. Rescue ballistic parachute systems produced by this company are labelled with GRS and also use rocket engine. *„The system is designed for the rescue of crew and aircraft, specifically for 1 and 2-seat light aircraft, ultralights and experimental aircraft and lately for General Aviation aircraft and unmanned aircraft. The product is certificated by LAA ČR, USA, Australia and the DULV, BAM Germany and complies with the conditions for purchase of rocket systems in the trade net of ČR, USA, JAR, Canada and EC.“[2][2]* With the rescue ballistic parachute system GRP the process of the extraction of the canopy is an innovation. The GRS canopy is kept contained in a harness until the suspension ropes are fully extended at 15-18m above the airplane. Time needed for the process is 0,4

to 0,7 s. This design minimises the danger of damage during deployment. The canopy is designed so that the time required to open it is as short as possible, and thus the system can be successfully used also at the lowest possible height. It is possible to choose from two GRS system designs. One of them is a dural tube with front and rear detachable laminate domes. Another possibility is a box made of fabric. Mounting points are provided on the lower sides of the dural tube. *„The canopy is folded into a harness which slides into the container. The rocket tube is mounted on top and protected by laminate cover. The rocket engine is connected to the harness by slings and to the firing handle by a cable. The handle is secured against incidental firing by a safety cable.“[3][2]* The system is manufactured for an operational life of 30 years under conditions of good maintenance and checks as given in the manual delivered with the system. In the event that the system has not been activated after 6 years, the owner is obliged to return the system to the manufacturer for service. Recommended temperature range to which the system can be exposed is above -40°C and below 60°C.

4. CKC-94 Emergency Escape System

CKC-94 presents a super-light ejection system which is designed first of all for low-speed light aircraft, trainers, agricultural and other light aircraft relating to general aviation. In case of a crisis, when the pilot pulls the ejection handle, the headrest with the parachute stowed in it is jettisoned. The headrest breaks the aircraft cockpit canopy and in 0.2 s deploys the parachute in the airflow. Simultaneously, the pilot is extracted out of the cockpit with the harness. The seat remains in the aircraft cockpit. This procedure is carried out fast enough so that the aircraft does not endanger the life of the pilot. Loads acting on the pilot during ejection do not exceed those allowable for parachutists. One of the system's advantages, in contrast to other systems where the seats are also rejected, is its smaller size. It may be used in the range of equivalent air speeds (EAS) from 60km/h to 400 km/h and altitudes from 7 to 4000 m. The seat has a stepwise height adjustment. The complete weight of the set does not exceed 28.5 kg. TheCKC-94 has an operational life of 20 years with routine maintenance to be carried out every 2 years.

5. EMERGENCY PARACHUTES ATL

Emergency parachutes ATL are parachutes produced by the Czech manufacturer MarS a.s.. Their four types of emergency parachutes are : ATL-88-1, ATL-88-90, ATL-88-92-S-1, ATL-88-98-S-1.

5.1. ATL-88-1

Canopy's surface is 36 m^2. The choice of parachutes with different weights are 5,9 kg, 6,8 kg a 6,9 kg (parachute's weight without portable bag). Dimensions of the packed parachute: 560x360x90 mm. Needful force to the pulling out of the ripcord is 23 to 97 N. Other parameter is vertical descent rate at the load of G = 77 kg is up to 5m/s. Swivelling through 360° takes 8,6s . The use of this parachute is limited to the weight of 115 kg (with full equipment and parachutist) and the maximum speed at which the parachute can be used is 277,8 km/h. Minimum permitted altitude at which the parachute can be used is 100 m (at aircraft speed of 110 km/h). Temperature range for this type of parachute is -40°C to 93,3°C.

5.2. ATL-88-90-1

Canopy's surface is 36 m^2. The choice of parachutes with different weights are: 5,9 kg, 6,8 kg, 6,9 kg (parachute's weight without portable bag). Dimensions of the packed parachute: 560x360x90 mm. Needful force to the pulling out of the ripcord is 23 to 97 N. One of the parameters is vertical descent rate at the load of G = 77 kg up to 5 m/s. Swivelling through 360° takes 8,6 s. The use of this

parachute is limited to the weight of 115kg (with full equipment and parachutist) and the maximum speed at which the parachute can be used is 277,8 km/h. Minimum permitted altitude at which the parachute can be used is 100 m (aircraft speed is 110 km/h). Temperature range for this type of parachute is -40°C to 93,3°C.

5.3. ATL-88-92-S-1

Canopy's surface is 36 m^2. The choice of parachutes with different weights are: 6,9 kg, 7,9 kg, 8,0 kg (parachute's weight without portable bag). Dimensions of the packed parachute : 680x360x90 mm. Needful force to the pulling out of the ripcord is 23 – 97 N. Vertical descent rate for ATL-88-92-S-1 at the load of G = 77 kg is up to 5 m/s. Swivelling through 360° takes 8,6 s. The use of this parachute is limited to the weight of 115kg (with full equipment and parachutist) and the maximum speed at which the parachute can be used is 277,8 km/h. Minimum permitted altitude at which parachute can be used is 100m (aircraft speed is 110 km/h). Temperature range for this type of parachute is -40°C to 93,3°C.

5.4. ATL-88-98-S-1

Canopy's surface is 36 m^2. Parachute's weight (without portable bag) is 8,2 kg. Dimensions of the packed parachute : 405x345x120 mm. Needful force to the pulling out of the ripcord is 23 až 97 N. Maximum vertical descent rate at the load of G = 77 kg is 5 m/s. Swiveling through 360° takes 8,6 s. The use of this parachute is limited to the weight of 115kg (with full equipment and parachutist) and the maximum speed at which the parachute can be used is 277,8 km/h. Minimum permitted altitude at which parachute can be used is 100m (aircraft speed is 100 km/h). Temperature range for this type of parachute is -40°C to 93,3°C.

6. Aviation accidents

Aviation accidents mentioned in the paper can be divided into three groups: aviation accidents where a rescue parachute system or personal emergency parachute was not available or was not used; aviation accidents where rescue parachute system was used; and aviation accidents where personal emergency parachute was used. The accidents mentioned in the paper have in common that the severity of the preceding critical events required the use of rescue elements, either ballistic rescue parachute systems or personal emergency parachutes. The first part of the chapter is dedicated to the aviation accidents where personal emergency parachutes were used. It lists and details accidents caused by pilots' lack of discipline or the lack of understanding of the situation in the air. In the first accident, collision of two gliders, all but one participant, a trainee in one of the gliders, were saved. Personal emergency parachutes were used, however; this trainee, apparently due to the stressful situation didn't even attempt to leave the aircraft. Another example given is an accident, when the pilot lost control over the aircraft that got into a sudden descent which he was unable to stop. The last mentioned accident was again a collision of gliders, which took place during a competition. One of the gliders was able to complete the flight, but the second pilot had to leave the glider. These accidents clearly show the advantage of having a pilot equipped with a personal emergency parachute. These are situations in which pilots lost control of the aircraft either due to failure to manage the plane, or due to a collision when the damage made it impossible to continue the flight. Next part of the mentioned chapter is dedicated to aviation accidents when rescue parachute system was used. Yet again we can decide that the only solution of a preceding critical situation when it occurred was the use of rescue parachute systems. In the first example the aircraft suddenly became uncontrollable due to structural damage. Because it suddenly got into an upside-down position, it would had been very difficult to use a personal emergency parachutes. Pilots were forced by the given situation to use rescue ballistic parachute system. In the second example, the aircraft got into a tailspin, however the pilot was not able to manage this situation. It's certain that a major contributor to the critical situation was failure of the

engine. Pilot saved himself by the use of a rescue system. In this document there are also accidents that point to the crew lacking training in handling of emergencies and usage of rescue systems. An example is an unintentional activation of the rescue ballistic parachute system by the pilot, which resulted that the aircraft was, after impact with the ground and being dragged by wind, damaged.
The use of rescue parachute systems as well as of personal emergency parachutes has its limitations. It is obviously appropriate in a situation that cannot be solved any other way to use rescue parachute systems outside of their limitations. In such cases, the system can lower the impact of the accident on the aircraft, reduce the level of potential injuries to the crew, even when the limits are exceeded, the crew can be saved with no injuries. The last part of the chapter dedicated to aviation accidents, analyses the ones without the use of rescue parachute systems or personal emergency parachutes. Right from the first example it is clear the importance of adequate training of the crew. Apparently, the crew was equipped with personal rescue parachutes; however it did not know how to open the cabin cover in emergency. This part also lists accidents caused by the aircraft going into a tailspin or a spiral.

7. COMPARISON AND LEGISLATION

There is a detailed description of legislation, standard orders and standards relating to parachute requirements. These standards are: TSO-C23f, TSO-C23d, SAE AS8015B Minimum Performance Standards for Parachute Assemblies and Components, Personnel, PIA TS 135 Performance Standards for Personnel Parachute Assemblies and Components.

7.1. Comparison of certain parameters

This part of the work is dedicated to the comparison of selected parameters of the rescue equipment and systems described in the work: emergency parachute systems, personal emergency parachutes and emergency escape systems.

Table 1 Comparison of certain parameters

	Emergency parachute systems	Personal emergency parachutes	Emergency escape system
Maximum speed for use (km/h)	140 – 365	277,8	60 - 400
Maximum weight for use (kg)	240 – 1800	115	-
Minimum height for use (m)	30 - 200	100	7

7.2. Benefits and drawbacks

Table 2 Benefits and drawbacks

	Personal emergency parachutes	Emergency parachute systems	Emergency escape system
Benefits	Lower installation costs	Easy activation without the need to leave the cockpit	Easy activation
	Installation in the aircraft not necessary	Comfortable landing	
Drawbacks	Necessity of leaving the cockpit in case of emergency	Necessary installation in the aircraft	Only certain types of aircraft are equipped
	Possible injuries during jump	Higher installation costs	
		Presence of pyrotechnical equipment	Presence of pyrotechnical equipment

8. CONCLUSION

From the studied material demonstrated in this work it can be concluded that aircraft equipped with rescue ballistic parachute systems, respectively pilots equipped with personal emergency parachutes, increases the likelihood of survival in the event of critical, dangerous situations in which an aircraft can get during the flight as well as increasing the likelihood for the aircraft to stay undamaged. From the work it can be suggested that these systems are sufficiently underrated in order to rescue or mitigate accidents even when height or weight restrictions have been exceeded. However, it is necessary, in accordance with the manufacturer's claim, to make decisions on the use or non-use of these systems flexibly as exceeding those limits might lead to an unsuccessful rescue. In terms of maintenance and overload of the pilot in the pre-flight preparation, when other elements must be checked, these systems are also convenient. Service life of such equipment is satisfactory with regular revision. In the aforementioned pre-flight preparation the system practically does not overload the pilot in any way. It can be argued that in terms of safety the advantage of using these systems or personal emergency parachutes is large, that can be confirmed by looking at the accidents described in this work. Each of the mentioned systems has its benefits and drawbacks. Personal emergency parachutes are the easiest form of equipment in case of emergencies; however, their use requires the largest effort. At the described types of ATL the lowest possible height for use is 100 m above the surface of the earth. The lowest possible height at which personal emergency parachutes can be used starts at 30m up to 200m. The highest speed at which emergency parachute systems can be used ranges from 140 to 365 km/h, in case of personal emergency parachutes it is 277, 8 km/h.
Comparing these parameters and the described advantages and disadvantages, it can be concluded that emergency parachute systems have greater utility than personal emergency parachutes. Although emergency escape systems are an interesting solution, they can only be used in certain types of aircrafts and they cannot be installed in the aircraft posteriorly by the pilot.

9. LITERATURE LIST

Books:

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