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Potential risks when performing aviation accident site inspection

Summary

The purpose of this article is to present the major risks accompanying visual inspection and rescue operations in relation to an aviation accident or other events with similar implications. Furthermore, the text presents, in a synthetic manner, the basic methods to protect potential inspection participants from the threats of the impact effects. The need for training on potential aviation accident hazards to inspection participants and rescue operations is also pointed out.

Keywords accident, flight safety, pressure tank, fire, aircraft, aviation fuel, security threats, visual inspection of the aircraft, pyrotechnics, hazardous materials, arming air

Introduction

As a result of accidents involving aircraft[1] (aircraft), with the effects described in the following sections, there are grounds to undertake rescue operations of people and property, followed by inspection of the scene in order to take further steps associated with the accident. For many of their participants, considering the previous dynamics of existing air accidents, it seems, that everything that was supposed to happen – happened. However, as confirmed in practice, nothing could be more wrong. Aviation accidents is only a contribution and initiation of events, which may, with the participation of aircraft equipment, have, a very real threat to the life and health of the participants and bystanders. That is why it seems very important at this point to determine the scale and sources of threats that should be encountered here, and thus counteract their negative effects.

Plane crash

Before we move on to an analysis of relevant risks arising from an accident or similar event, it seems well founded, for the record, to define what is meant by accident within the meaning of the provisions contained in the literature [13, 14].

A plane crash means a related event during the operation of an aircraft, which in the case of manned aircraft, takes place between the time a person boards the aircraft, with the intention of flight, until disembarkation by such persons. In the case of an unmanned aircraft is done from the time the aircraft is ready to move with the purpose of flight until it stops at the end of the flight and the propulsion system is turned off.

For an accident other than those listed above, the following conditions must be met, individually or jointly:

1. A person on board the aircraft fatally or seriously injured as a result of
   - being on board the aircraft or
   - direct contact with any part of the aircraft, including parts which have become detached from the aircraft, or
   - direct exposure to an aircraft engine blast (propulsion system), except when the injuries are from natural causes, self-inflicted or inflicted by other persons, or when the injuries are outside the areas normally available to the passengers and crew members.
2. The aircraft sustains damage or were its destroyed structural element adversely affect the structural strength, or characteristics of the level of performance and would normally require major repair or replacement of the

1 An aircraft is a technical device heavier than air, moving up in the atmosphere as a result of the dynamic interaction of aerofoils or by using the vertical component generated directly within the propulsion system without taking into account impact with the ground.

affected component, except for engine failure or damage, when the damage is limited to a single engine, (including its cowlings or accessories), propellers, wing tips, antennas, probes, vanes, tires, brakes, wheels, fairings, panels, landing gear doors, windscreens, aircraft skin (such as small dents or holes) or minor damages main rotor, tail rotor blades, landing gear, and those resulting from hail or bird strike (including holes in the radome).

3. The aircraft is missing or access is completely impossible.

It should be noted, that in certain accidents, an aircraft (crew, maintenance or bystanders) whereas the effects of the accident, may also pose a threat, as described in the article, although not fulfil the conditions laid down in the quoted definition. This can happen even in the event of incidents arising during operation in the air or on the ground, when for reasons of external or internal, the circumstances mentioned in the definition quoted above, are encountered but with no intention of flight.

Evacuation of people

Regardless of impact and size of the accident, the main purpose of the first activities of all the emergency services and law enforcement is to save lives and health of participants of the accident and bystanders. Therefore, on arrival at the scene, the fundamental and priority of each formation is the evacuation of people at risk (injured). In these circumstances, the safety of participants in the rescue operation and incident safety should be ensured. It is extremely difficult due to the shortage of time in which the rescuers and those securing the dynamics and unpredictable action operate.

An important element of these activities is to reduce interference with other components after an aircraft accident (cutting, tearing) and execute only actions aimed at saving human life and health. The same purpose should serve any movement of aircraft components. This action will allow for reliable performance inspection and follow up by bodies established for this purpose (SCAAI[2], Committee for Investigation of National Aviation Accidents[3], Police, Military Police, and Prosecutor's Office) in accordance with the actual state at the time of the accident. As the existing possibilities it seems reasonable to record significant salvage operations on this basis of determining the scope of interference in the existing services at the scene facts. If this is not possible, it is advisable to withdraw the participants from the rescue action statements (statements) that will allow during the proceedings to restore the level of intervention with the existing structure of the aircraft and other items.

At the same time, keeping in mind further danger, you should create a safety zone allowing for freedom of further proceedings related to ensuring the full safety of bystanders and not involved in the doing.

Destructive factors

Depending on the course, scope and size of the accident, the following destructive factors that may affect people and constitute the main source of possible injuries of various types are to be expected. These should include in particular, the following:

- thermal factors
- mechanical factors
- pressure impact factors
- chemical agents
- electric current or discharged electric charges
- electromagnetic radiation
- radioactive agents.

It is clear the effects of some of these factors simultaneously must be taken into account, resulting from the nature of their activities and the specifics of the proceedings following an air accident and greatly complicate the situation.

Fire hazard

As the general principles of fire safety show, very simply, the general cause of fire is fulfilled by three basic conditions: combustible material, access to air, initiation of the fire. Fuel as a flammable material will be discussed in the next section. But this is not the only potential or primary source of fire. As a result of an air accident, it is possible to ignite other combustible materials, e.g. due to release of heat energy from working engines or a heated oil spill. The high temperature in contact, e.g. of dry ground terrain, clothing, carpet upholstery, paper etc., can cause a fire, initiating both immediately after the occurrence of the accident, and after some time of its occurrence. Thus, in the course of any action, on the scene there must be fire protection, possible for immediate use in the event of a fire hotbed.

In a fire hazard, oxygen installations deserve particular attention (tanks). Released oxygen in contact with flammable material – fuel, oil – is easily ignitable even at normal ambient temperature.

A specific risk is the release of toxic materials from fire fumes. This applies in particular to plastic, paints

2 The State Commission on Aircraft Accident Investigation – the committee responsible for the investigation of accidents in civil aviation.

3 Aircraft Accident Investigation Commission of the State Aviation – the committee responsible for aviation accident investigation of the state (Aviation Armed Forces, the Police, Border Guard).

and composites, and any insulating and damping, which are increasingly present in the construction of aircraft. It should be noted that the threat does not decrease in a situation where the materials do not burn in an open fire, but smoulder, especially in confined spaces.

Aviation fuel

Aviation fuel as a combustible pose the greatest potential risk of fire during an accident and after its occurrence. In aircraft, depending on the engine type, various type of fuels are used, as follows: Aviation gasoline (or car) in the reciprocating engines or kerosene in the turbine engines (jet, turbojet). It should be noted that the probability of fire is dependent on several factors such as fuel properties, ambient temperature, evaporating area (surface of the fuel spillage) and the like.

Both fuel and other working fluids for their release does not constitute a direct toxic threat; they do not contain any substances immediately dangerous to life and health. These measures may, however, in the case of direct and prolonged contact with the human body (mucous membranes, skin) cause skin or upper respiratory irritation.

The above-mentioned substances are, however, a serious environmental hazard in the event of leaks to the atmosphere or ground. Therefore, in order to minimize the impact of these measures on people and the environment, the release should be prevent and the spread in the event of leaks should be minimized.

Fig. 1. Securing the accident scene before the fire by spraying a blanket of foam.

Electric current

Usually when an aircraft accident ends with a collision with the ground the propulsion unit is stopped (propellers, engines, transmissions), which constitutes the primary[4] source of on-board source of electricity, DC and AC. In these situations, the only active DC power source is usually the on-board battery (battery pack). Depending on the size and type of aircraft the battery network found is 12-28 volts and does not constitute a serious direct threat to the health and life of bystanders in the case of shock. However, the remaining voltage in the network poses a serious threat to the initiation of fire, in particular if in the accident there occurred simultaneously electrical wires or electrical appliances and leaking fuel tanks or other flammable hydraulic fluids. This can cause sparking and shorting, which is a direct prerequisite to the fire.

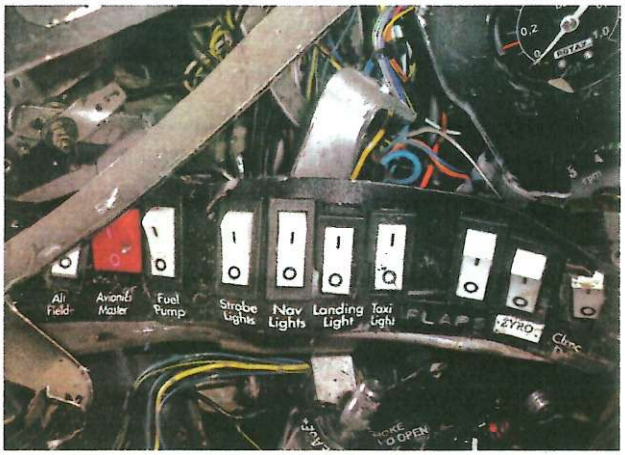

Fig. 2. Electric switches for light aircraft in position off.

In light of the above, one of the first steps upon arrival at the place of the event is the disconnection of the on-board electrical power sources. This is possible by using the main switch in the cockpit. However, its location, for those unfamiliar with the construction of a particular aircraft type, may pose natural problems in these circumstances, in particular when there is significant destruction to the aircraft or an unnatural position. Usually the main switch of the electrical system is described using the following words: "network", "battery", "storage cell.", "power supply", "power", "master", etc. Frequently all the switches of this type are disengaged in the down position; it is effective to switch all of the switches to the lower position (taking into account the actual position of the aircraft at the time of an event).

A more effective and radical solution in this case is directly disconnecting on-board terminals from the battery and removing it. Its location is also easy. Aircraft manufacturers usually mark the location of the battery installation using an appropriate inscription. Often in such a way as to make access to the battery possible from the outside through a marked hatch. The place of installation of the battery can also be the back, inside

4 The current sources generated on board the aircraft, of which only electricity is transformed for other voltages and frequencies.

part of the fuselage, to which access is possible only after removal of the seats or covers or, in the case of light aircraft, engine compartment.

Fig. 3. Sample location of the battery pack on board the Mi-2 helicopter in front of the fuselage hatch.

During the disconnection and removal of the battery, special care must be taken, as it could be damaged and as well be a source of discharge of aggressive substances, e.g. in the case of lead-acid batteries. It should be noted that on-board systems do not have internal protection systems to allow disconnecting the on-board power source in the event of an overload, usually associated with an air accident.

Electromagnetic radiation

Sources of electromagnetic radiation on an aircraft may be in particular:

1. Radar equipment located generally in the front or underside of the aircraft fuselage; covered with a non-metallic material (plastic).
2. Radio equipment (radios, walkie-talkies), whose antennas are mounted on the outer surface of the fuselage. Their shape is of short rods, sabre bars (flat), wires.
3. Other special equipment – a radio altimeter, Doppler speed measuring devices, etc. Their antennas are usually shaped as slightly convex surfaces with a diameter of several centimeters.

Electromagnetic radiation emitters are marked with warning inscriptions and symbols on the display. On account of the way of powering (atypical voltages), after an air crash, at the time of the interruption, the work of the propulsion system is switched to a closed state. However, it cannot be ruled out that despite the current case, some sources still work (batteries, converters, transformers), which allows the operation of these devices (especially radio). Only turning them off or powering down the on-board equipment is the guarantee that they are disabled.

The issue of the high strength electromagnetic radiation is a major threat to the health of people in their immediate vicinity. This is particularly dangerous when people are standing a short distance from the transmitters of the devices for a long time. Before it can be ascertained that these devices are disabled and do not present a danger, they should be avoided during the execution of operations on the direction of radiation emission from the antennas to the listed devices.

Pressure Vessels

On board almost every aircraft are pressure vessels and installations containing gas or liquid under high pressure. The amount of this pressure can range from a few up to tens of atmospheres. At the time an accident, due to mechanical impact, pressure vessels and installations may be depressurised. However, in a large proportion of cases they retain their seal, and thus the gas pressure or the working fluid remains at a similar level as in normal operation. However, their construction may be seriously weakened as a result of an accident. The result of the release of an agent under high pressure may occur even small and accidental mechanical or thermal facters during examination or other action. This represents a very serious threat to people living in the vicinity, in the case of a sudden and unintended leak of these components. The most important units of this type are in particular:

- bottles containing air, oxygen, extinguishing agents, nitrogen or other working gases,
- hydraulic reservoirs containing gas and hydraulic fluid under pressure,
- shock absorbers containing liquid and gas under high pressure and sometimes the springs which can be tensioned,
- oil tanks or other working medium that outside pressure may be elevated temperature,
- on-board installations of "undigested pressure" persistently in the aforementioned operating ranges (hydraulic, pneumatic, braking, etc.).

Storage tanks of compressed gases or liquids are generally spherical or cylindrical and are usually painted in bright colors according to the substance (e.g. cylinders with oxygen – blue, fire bottles – red). They have a charging connector in the form of a blind valve (cap). They can also be fitted with pressure gauges reflecting the prevailing pressure inside.

Shock absorbers and dampers have a structure similar to shock absorbers used in vehicles. Their size depends on the size and weight of the aircraft. Like other compressed gas tanks, they have clearly identified charging valves.

Extremely dangerous in such circumstances is unconsciously breaking a charging valve of a pressure tank. Therefore, it is reasonable and advised not to touch or move any equipment that may be a pressure source.

Fig. 4. Different pressure storage tanks; a) ruptured on-board fire extinguisher, b) oil tank – measuring glass indicates the level of oil, c) main landing gear shock absorber helicopter, d) a compressed gas cylinder – charging valve.

Radioactive materials

On board an aircraft, there may be sources of radioactive radiation. In older aircraft types radioactive material was used in paints used to paint the flight instruments to ensure that they glow at night. Therefore, in case of damage to such indicators, in particular glass breakage of the covers of these devices, do not allow contact with the paint found on the markings indicators and arrows with the body and absorbance of the substance contained therein to the human body. It should be noted that the amount of radioactive substance is minimal but in extreme cases of prolonged and immediate contact may cause a harmful effect.

Detection systems, aircraft anti-icing systems typically are mounted in the engine inlets or fan, as places most vulnerable to the formation of ice. They have the shape of small cylinders and are a source of radioactive isotopes. During normal operation, the scope of impact on people, because of their location, is virtually zero. After normal flight, these sources are protected by radiation shields for persons serving the aircraft. However, at the time of an accident they can be damaged and thus can lead to a release of radioactive material. This risk is particularly important in case of fire or explosion of the aircraft, which could lead to a completely uncontrolled release of the radioactive substance.

Fig. 5. Location of the dismantled icing siren on a Mi-2 helicopter and a view of the siren, clearly marked as a source of radioactive radiation.

Therefore, during examination, to be found are radiation sources of this type present in the aircraft and to determine whether they have not been damaged. If possible, secure these sources, minimizing their impact on people, and then notify the competent national authorities responsible for radiological safety in order to ultimately safeguard and neutralize the radiation sources. The sources of radioactive radiation are labeled from common and required markings (Fig. 5). Their housing may also include separate danger inscriptions.

Pyrotechnics, rescue systems and equipment

In many aircraft they are used pyrotechnic substances which could be a real source of danger in the event of sudden and unintended detonation. The typical places where they can be used pyrotechnics are the following:

- caps of tanks of extinguishing agents, opening the flow of the extinguishing agent to the danger during fire in the aircraft compartment
- signal pistols which are an integral aircraft equipment or used as a flare gun containing these substances
- release systems for water rescue and evacuation, for example, to release gas in pneumatic floats, emergency rafts, etc.
- unused rescue systems used in hazardous situations in flight, in particular in light and ultralight aircraft, gliders, hang-gliders and other light aircraft structures
- unused ejection systems used for emergency exit from an aircraft in case of immediate danger.

In the case of identification of such a system on board an involved aircraft, it is reasonable not to touch any of these components. In addition, it is necessary to disconnect them from the on-board electrical network. To ensure complete safety, do not move in the working

area (where these devices are working) or make any manipulation in the immediate vicinity of the device. Specialists should be brought in to provide security of these devices in a sustainable manner by setting up blockades, keepers or their safe removal.

Fig. 6. Stationary installation of fire suppression storage containers (1), pyrocartridge releasing fire extinguishing agent (2) pressure gauges indicating the pressure in the cylinders (3).

Fig. 7. Rescue system mounted on a paraglider carriage. Labels clearly indicate the threat posed by the parachute rescue system.

A separate large and complex issue is the threat associated with weapons that can be carried on board military aircraft (also other types of government aircraft) during an accident. The degree of potential danger depends on the type of munitions carried on-board the aircraft: armament, missiles, bombs and so on. While they will not detonate during an accident, this must be considered once the accident has occurred. The disruptive factors of an accident (overload, stress, temperature, etc.) can decrease the effect of safeguards against spontaneous detonation. Thus, after identifying weapons on board an aircraft there should be far-reaching precautions for further action. In particular, it is reasonable to disconnect the weapons power supply (or the entire electrical network) and provide protection against mechanical impact. Until disarmament by professionals, refrain from of any action in the area of influence of possible danger from the munitions.

Mechanical hazards

The aircraft, depending on its size, is a heterogeneous and multi-pieced metal body, or other materials of various size and high strength. At the time of the accident, depending on its dynamics, the aircraft is more or less distorted, which may be important for its continued strength. The destruction of the main elements of strength, is often followed by the disruption of the structure and its dismemberment. After impact with the ground, the aircraft is usually in a position completely unnatural. In this arrangement, its position may be definitely unstable, threatening movements of various kinds, even as a result of a slight vibration. Therefore, the stabilization of the main elements (biggest) of aircraft is appropriate in the initial phase of the rescue operation and inspection to prevent its further shipment.

As a result of the destruction, disruption of the continuity of structures (plates, caissons, girders) takes place. They provide basic, extremely high risk for participants in activities due to the possibility of injury by sharp edges of sheet metal. Special caution is deserved on other mechanical elements such as guides, springs, pendulum, snaps, etc. This is due to the fact that as a result of even a small pulse, components can start (start) by themselves. Thus suddenly they can trigger a large amount of stored mechanical energy in an uncontrolled progress. In this way, it can easily lead to mechanical damage to people within the range of these components.

Hazardous materials

On board an aircraft involved in an accident, there can be dangerous goods whose transport is allowed after meeting the relevant requirements. In accordance with the relevant provisions of [16-18] for dangerous goods, articles or substances that may pose a threat to the health and which are included in the list of dangerous goods contained in the technical Instructions [17] or have been classified in accordance with these instructions, for the safety, property or the environment, should be considered. These are in particular:

- explosives
- gases
- flammable liquids
- solids, flammable; substances liable to spontaneous combustion; substances which produce flammable gases on contact with water
- oxidising substances; organic peroxides
- poisonous and infectious substances
- radioactive material
- corrosives
- various dangerous substances and articles, including environmentally hazardous substances.

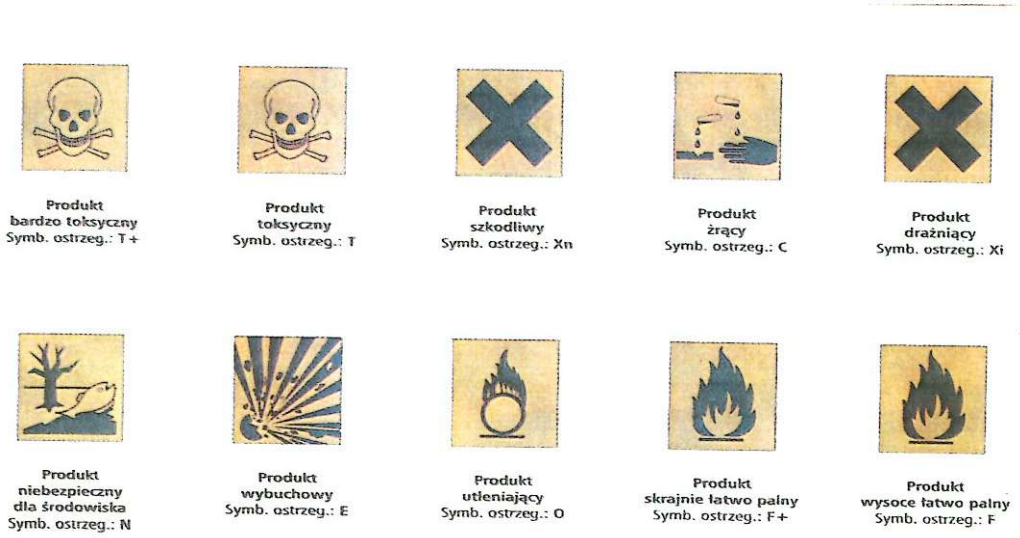

Fig. 8. Commonly used markings for hazardous materials.

The above-mentioned materials and substances must be packed in a specific way using packaging for the transport of dangerous goods by air. These packages meet the appropriate requirements ensuring integrity during transport under normal flight conditions due to changes in temperature, humidity, pressure or vibration. However, these packages have a limited ability to retain their integrity and protection of hazardous materials at the time of an aircraft accident.

Thus, after the occurrence of an aviation accident, in the course of preliminary activities, one should reveal, whether on board, hazardous materials are not found. This can be done on the basis of special labels located on the packaging of these materials. These labels clearly identify the hazardous materials. In addition, aircraft operators (carriers) and their crew should have information about the transport of dangerous materials. They also are required to have and provide waybills containing information relating to any hazardous materials being transported. At the same time, at the time of the accident aircraft or serious incident, in which dangerous goods carried as cargo could be involved, the aircraft operator, having been informed of the incident, must immediately provide responsive emergency services in the event of information of dangerous goods on board. However, such action, essential for the secure identification of possible threats, may be subject to delay.

All hazardous materials must be transported, outside the crew and passenger cabin, in the cargo compartment and, like other cargo, secured against movement during the flight. Hazardous materials should be expected in larger aircraft having appropriate cargo spaces.

However, it can not be excluded that even in small aircraft, hazardous materials are transported in a manner inconsistent with applicable regulations. These may include, in particular: small amounts of fuel, oil or other substances in packages that do not provide their inviolability, e.g. in cans, jars, etc. Hence, before performing rescue work and identification, whether in the interior of the aircraft, including the cabin crew or passengers and luggage compartments, they were not released any dangerous materials (substances), which were in contravention of applicable regulations in the field of air transport.

External threats

An aircraft accident can cause damage to the terrain infrastructure and other objects, in particular: building construction, installation, stand and other obstacles (vehicles, containers, etc.). As a result, collision of the aircraft with these elements, beyond their destruction, causes damage of varying degrees to these elements and a possible weakening their current strength. Before taking action on an aircraft it must be certain that damage to the infrastructure terrain and other objects do not create risks for people living in their proximity. In justified cases it is necessary to strengthen (stabilize) structures or demolish them to the extent necessary.

Similar threats can cause all sorts of damage to ground installations, in particular electrical and gas installations. The impact of electric current or gas as a result of faulty wiring, pose a real risk of fire, an in extreme cases – explosion. Only by cutting off the utilities can guarantee safety in the area of aviation accidents.

Summary

The content of the article does not cover all issues related to the potential dangers that may arise during the inspection of an aircraft after an accident and

performance of rescue operations. The main risks and basic ways to avoid injury during activities related to the close-up surveys and conducting rescue operations are indicated. The awareness and knowledge of the participants in these activities with existing potential threats may allow for the safe execution of all the necessary procedural steps, in particular the visual inspection, without jeopardizing the health and lives of the those doing the work.

Source

Figs. 1, 3–5: SCAAI report
Figs. 2, 6, 7: author
Fig. 8: symbols commonly available on the basis of the European Parliament and Council Regulation (EC) no 1272/2008 of 16 December 2008 on classification, labelling and packaging of substances and mixtures, amending and repealing Directive 67/548/EEC and 1999/45/EC and amending Regulation (EC) No 1907/2006

Translation Ronald Scott Henderson

Bibliography

1. Domicz J., Szutowski L.: Aircraft pilot handbook. Technika. Poznań 1998.
2. Dudek P., Włodarczyk Z.: Paragliding. Arete Publishing House. Bydgoszcz, 2006.
3. Karsznicki K.: Legal aspects of air accident investigations conducted in the context of criminal proceedings. Prokuratura i Prawo. 10/2012.
4. Klich E.: Flight safety. Accidents, causes, prevention. Puławy, 1998.
5. Konieczka R.: Danger for people and the environment, related to plane crash. Presentation. Transportation problems. VI International Scientific Conference, Katowice 06.27.2014.
6. Konieczka R.: The specificity of issuing opinions by a court expert in the field of aviation. Twelfth National Conference on Forensic Expert. The Association of Economic Appraisers. Czestochowa, in April 2015.
7. Konieczka R.: The key issues of separation proceedings related to the accident aviation. Aviation Law and Technology. University Of Rzeszów Publishing House. Rzeszów, 2015.
8. Witkowski R.: Construction and piloting helicopters. WKiŁ. Warsaw, 1986.
9. Legal aspects of the safety investigation in the light of the Decree 996/2010. Collective work edited by A. Konert. Lazarski University Publishing House. Warsaw, 2013.
10. Basics of organization and methodology of air accident investigations in civil aviation of Poland. Collective work edited by A. Milkiewicz. Warsaw 2001.
11. Teaching materials on the training of experts of the State Commission on Aircraft Accident Investigation. Warsaw, (not published).
12. Act of 3 July 2002. Aviation Law (Dz.U. of 2002. No. 130, item. 1112). Uniform text – announcement of the Marshal of the Sejm of the Republic of Polish of 13 September 2013. On the announcement of the uniform text of the Act – Aviation law, Official Gazette of the Republic of Polish of 28 November 2013., Pos. 1393.
13. Regulation of the Minister of Infrastructure of 18 January 2007. On accidents and incidents (Dz.U. of 2003. no. 35 pos. 225).
14. Regulation of the European Parliament and of the Council of the EU no. 996/2010 on the investigation of accidents and incidents in civil aviation and prevent them and repealing Directive 94/56 / W.
15. Accident and Incident Investigation aircraft. Annex 13 to the Convention on International Civil Aviation. July 2010 Tenth Edition. International Civil Aviation Organization.
16. Safe transport of dangerous goods by air. Annex 18 to the Convention on International Civil Aviation. July 2011 Tenth Edition. International Civil Aviation Organization.
17. Technical Instructions for the Safe Transport of Dangerous Goods by Air. (Doc 9284).
18. Regulation of the Minister of Transport, Construction and Maritime Economy of 13 July 2012. On the detailed conditions of implementation of international flights with hazardous materials (Dz.U. 2012 pos. 898).
19. Aviation Flight Safety Manual of the Polish Armed Forces. Warsaw, 2004.