DANGERS OF STATIC ELECTRICITY AND PROTECTION IN AVIATION

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Abstract: This paper deals with the danger situations caused by static electricity and offers some basic information on its origin in different environment. It also gives some less known facts about this always present danger and illustrates, through examples from practice, static electricity, its dangers and consequences on aviation, as well as preventive measures for fire and explosion protection.

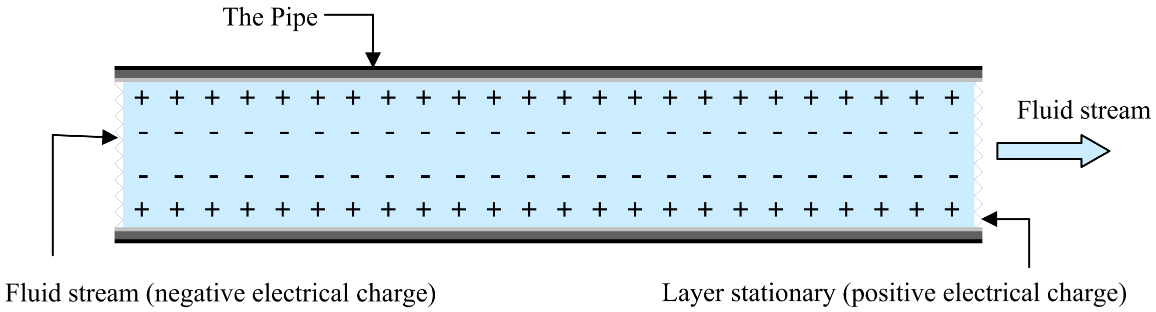
Key words: static electricity, fire, explosion, airplane, accident

1. INTRODUCTION

If two substances are in contact and one of them is an insulator, splitting up these substances will cause static electricity. In normal conditions these substances are electric neutral, but during moving the object, electrons leave their orbits and pass from one surface to another, what causes the difference in electrical charge. One substance is positive electrified (has deficit of electrons) and the other substance is negative electrified (has surplus of electrons). Electrical charge depends on the speed of surface friction, size of contact area, humidity, etc. The object which has electrostatic charge tends to has neutral electrostatic charge, what results with sparkling, which can be very dangerous in explosive atmosphere. If energy of the spark is big enough to start detonation, consequences are easly predictable.

1.1 Fluid circulation in the pipeline and static electricity

When fluid circulate in a pipeline, in fluid also genesis static electricity. At different points at the cross section pipeline fluid bubbles speed isn't identical. Top speed is at the center line but at the



Picture 1: Genesis static electricity in fluid pipeline

said pipeline speed is much lesser. Because of that, and because friction fluid bubbles, at the poor conduct fluid split up electrical charge at positive and negative ion, and accumulate static electricity.

If this poor conduct fluid go trough grounded pipeline, in fluid arising positive electrical charge, and near the entrance in ungrounded fuel tank, at the inside fuel tank arising negative electrical charge and at the outside fuel tank arising positive electrical charge. When electrical charge accumulate and electric potential in fuel tank arise to determine level, the spark can jumping from:

- Outside fuel tank to the ground, or
- Inside surface of the fuel the side of fuel tank (free voltage at area fluid).

Because of the free voltage at fluid to surface, fuel tanking with grounded fuel-carrying vehicle isn't a guarantee to eliminate static electricity. The spark can jump from surface of the fuel to the side of fuel tank, and if energy of the spark is big enough, it can to start detonation in explosive atmosphere.

1.2 Aircraft and static electricity

Aircraft are always positively charged when flying. At 10,000 meters altitude (the normal flying altitude for commercial jet aircraft), the atmosphere naturally carries a positive charge of approximately 100,000 Volt. This is due to the electrical field that exists between the Earth and the ionosphere, the ionosphere being approximately 300,000 Volt. The positive charge that is induced by friction between the object and air such as an airplane flying through the atmosphere is, of course, added to the existing 100,000 Volt.

Picture 2: Aircraft can acquire a charge of one million Volt or more [8]

The air humidity at 10,000 meters altitude is extremely low and therefore is a perfect environment to foster huge electrostatic charges. It is reasonable to assume that an aircraft can acquire a charge of one million Volt or more, which it shares with the passengers inside the aircraft. [1]

When an aircraft lands during dry conditions, huge sparks are released to Earth as soon as the aircraft touches down. These discharge sparks to Earth substantiate the potency of the charge on the aircraft.

1.3 Static electricity of the humans

Human body is an electro conductor and as such it accumulates static electricity up to several hundreds Volts in a dry atmosphere. Electrostatic charge during the walk is created from the contact of a shoe and the material covering the ground. Electric capacity of an average human body is about 250 pF and it is directly connected with both the human's height (not weight) and the material covering the ground one walks on. Experiments confirmed that walk of the man in the rubber shoes down the concrete ground creates the charge of 1,000 V, walk down the woolen carpet creates the charge of 14,000 V, while getting out of the plastic chare creates the charge of 18, 400 V. It has also been determined that complete discharge of a condenser is performed within 50 seconds if one stands up and quickly walk up to some grounded object, after second or two it still has the voltage of around 40 kV. If one only lifts a little from an upholstered chare (about 1 centimeter from the seat) he is charged with the electricity of 10 kV, and if he would reach his arm to get hold of some grounded object, the jump of a spark occurs. Since in such conditions the capacity of a man towards the chair is 2000 pF, under the charge of 10 kV the man is a carrier of the energy of 0.1 J, which is energy high enough for detonation of an explosive atmosphere. [2]

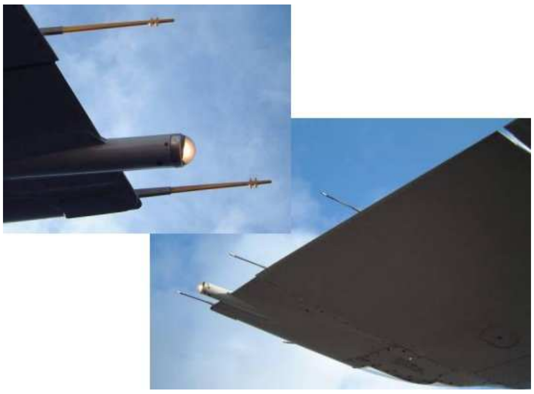
Picture 3: Human body is an electro conductor and as such it accumulates static electricity up to several hundreds Volts [9]

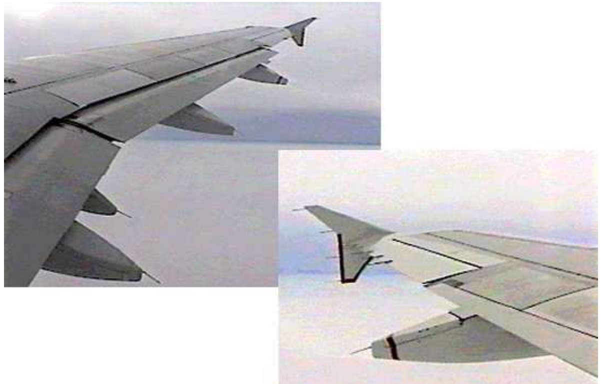
Humans are able to sense the effect of the electrostatic charge during the discharge of the static electricity of 1mJ, body capacity of 300 pF and body charge with static electricity towards the body of 2,500 V. The muscle contraction because of the discharge of the static electricity can be confirmed starting with 10 mJ, and nowadays the energy of 100 mJ is considered as the highest value for the electroshocks, although there are separate experiences confirming that persons were able to endure the discharges with the energy of more than several J. Beside initiating electroshocks, discharge of the static electricity also leads to secondary injuries, which are result of uncontrolled movements and have as their consequence injuries at work, occurring due to falls or misuse of working tools. [3]

2. PREVENTIVE PROTECTIVE MEASURES

Static electricity has a negative influence on a safe work of the navigation and other instruments and because of that aircraft have installed systems for elimination of harmful influence of the static electricity. On wings and flaps of some civil aircraft it is possible to notice certain extensions similar to antennas the function of which is to reduce the influence of the static electricity on the aircraft in flight.

These extensions – «antennas» provide additional path for discarding of the electron surpluses form the aircraft structure back into the atmosphere.





Pictures 4 and 5: Protection from the static electricity at the wings of aircraft type "Boeing 737" and "Airbus A320" [7]

With the aim of reducing the harmful influence of static electricity during the pouring of the fuel from the tank track into the aircraft, opening of the wing fuel tank on big aircraft is situated at the bottom side of the aircraft wing. Fuel contains antistatic additives, while connecting of the aircraft with the tank track using a cable for equalization of electrostatic potential is obligatory. Application of this measure is very questionable, because grounding creates the possibility for sudden or cumulative discharge, that is sparkling [4], which may be a crucial factor for detonation of inflammable or explosive mixture of fumes of inflammable liquids or gases and the air in the inflammable atmosphere.

Pictures 6 and 7: Static electricity as a cause for fire on the aircraft "Towerair"

Workers in charge of aircraft tanking must wear antistatic clothes and shoes, and training for secure performance of the work is something that goes without saying. But despite all this, fires do happen, most often due to so called "human factor", and one such fire occurred at the airport Belgrade on 5 May 2000.

On that day, at the station in front of the hanger of "JAT"'s General Aviation when the fire occurred, the air temperature was + 21 degrees centigrade, relative air humidity 34%, and southeast wind of 2-3 meters per second blew. Aircraft type "Beechcraft", registration mark YU BHK, was at the station in front of the hanger undergoing the preparations for the flight. The tanking of the aircraft was performed in such a manner that the fuel had been poured from the 200 liters barrel into the 10 liter canister, and the canister was carried to the aircraft and put on the aircraft wing. The fuel from the canister was poured into the aircraft tank through the opening of the tank that was situated at the upper side of the wing and the tin funnel covered with deer fur. The aircraft was not grounded, and in order not to damage the paint at the aircraft wing with the canister, the workers put a synthetics pad somewhat wider than the bottom of the canister. After numerous carrying of the canister from the barrel to the aircraft wing and back, as well as the constant placing of the canister on the synthetic pad, the static electricity was created on the body of a man who performed the pouring of the fuel. After he had finished the pouring, with an intention to remove the funnel from the aircraft tank, a spark of static electricity jumped from the man's hand and set fire to petrol fumes that evaporated from the funnel. [5]

Aircraft fuel supply systems are very sensitive spots and any damage, as a rule, causes the fire. Even during the process of design and construction, these systems are under the special care of the constructors, they are made of special materials which do not produce sparks and reduce the harmful influence of the static electricity, but sometimes all that is not good enough to ensure complete safety and security of the system.

Pictures 8 and 9: "Boeing 747-100" before [10] and after crash [11]

On 17 July 1996, commercial aircraft of the airline "TWA", on the flight number 800, operated from New York to Paris set on fire due to the explosion of the central fuel tank. All 212 passengers and 18 crew members of the aircraft type "Boeing 747-100" were dead. There were several different theories about the crash of this aircraft – from the terrorist attack, bomb onboard the aircraft, mechanical malfunctioning of the aircraft, to the theory that the aircraft was shoot down with the missile by mistake. Within the serious expert circles, [6] static electricity and the spark arising in the fuel pump was taken into consideration as the possible cause of the accident. The cause for this aircraft crash has not been fully cleared up yet.

CONCLUSION

Static electricity is always considered as the primary danger. Once it appears, static electricity, as a rule, provokes unwanted effects – electroshocks, leads to the secondary injuries as a consequence of the uncontrolled movements, and in an explosive atmosphere, it provokes fires and explosions. To prevent the unwanted effects, first of all means to familiarize oneself with the genesis of static electricity, and then to follow all prescribed measures for protection against fire and explosion.

The aim of this work, in that sense, was to move a step further and bring this issue closer to the public of experts.

LITERATURE

[1] Peter Staheli, http://www.users.bigpond.com/lifelogics/static_electricity.htm
[2] Radovan M. Jovanov „Elektrostatičko naelektrisanje čoveka kao uzrok paljenja eksplozivne atmosfere“, ZOP 96, Novi Sad, 1996, str. 74
[3] Karaba I, Jovo S. „Statički elektricitet i njegova štetna dejstva“, ZOP 96, Novi Sad, 1996, str. 69
[4] Mićo V. Gaćanović „Tendencija razvoja eliminacije statičkog elektriciteta“, ZOP 96, Novi Sad, 1996, str. 81
[5] Martin Djovčoš „Opasnost na aerodromu“, STUDIO LINE, Beograd, 2004, str. 24
[6] Testimony of Jim Hall, Chairman National Transportation Safety Board before the Subcommittee on Aviation Committee on Transportation and Infrastructure regarding Accident Involving TWA Flight 800, July 10, 1997
[7] http://www.aerospaceweb.org/question/design/q0234.shtml
[8] http://www.mcgillcorp.com/news/images/Alcore-Strikegrid-Lightning.jpg
[9] http://images.thedreamer.nl/241205-1.jpg
[10] http://www.airlinemuseum.com/catalog/images/products/SJTWA180.jpg
[11] http://baaa-acro.com/photos/B747-100-TWA-New%20York.jpg

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