- Electrical Hazards -

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Electricity is a dangerous thing, be it dynamic or static electricity. Several accidents caused by one or other type have already occurred with aircrafts and rockets. Some of them proven and others considered very likely caused by them.

1) **Dynamic Electricity** - On this part, the electrical current is the principal variable, which, depending on the path through the human body and its resistive state, can lead someone to death with just a few thousandths of Amps (mA).

Electrical current can be continuous (DC) and alternating (AC). The current in a car is generated by voltages of 12V (battery) and 14V (generator). This difference of 2V between generator and battery is necessary so that the generator can charge the battery. Once moving, the voltage applied to the electrical circuitry of the car is just that of the generator.

In the case of aircraft, we have 28VDC, 115V/400 Hz and 26V/400 Hz. The use of 400 Hz frequency is to decrease the weight of the iron used in generators. The higher the frequency, the lower the weight, and weight reduction in aerospace products (Aeronautics and space) is important.

The problem of using alternating current in aircraft is that it can produce electromagnetic interference on the systems, and this represents danger. But the current design techniques have decreased quite this possibility.

The problem for humans is the so called electric shock, which can be defined as a sudden and accidental stimulus in the nervous system of the human body, caused by an electrical current, where the body is part of an electrical circuit.

Ohm's law governs the variables of a circuit, being given by

$$V = RI \qquad (1)$$

Where V = voltage in Volts (V);

R: resistance (Ω); and

I: electrical current (A).

We think it is clear that the problem of the electric shock is concentrated in the electrical current, and not in the voltage. Keep this well.

The severity of the electric shock depends on the following factors:

a) the intensity of the current flowing through the human body;

b) the current trajectory along the body; and

c) the duration of the current flowing through the body.

The fatal current depends on the voltage and on the resistance of the body, and this depends on the conditions of the external environment that surrounds it. A wet skin provides less resistance to the current.

The literature about this subject presents (keep this picture available somewhere) the following effects produced by alternating current (AC) of 60 Hz and/or by a direct current (DC).

- **0 - 1mA AC; 0 - 4mA DC** - there is already a noticeable shock, but inconsequential;
- **1 - 4mA AC, 4 - 15mA DC** - the person has an involuntary reflex, moving the body part that receives the current, he could lose his balance and finally suffer fall, but there is no severe effects;
- **4 - 21mA AC, 15 - 80mA DC** - involuntary reflex with very strong possibility of injury. The victim may not be able to get rid of the source voltage (clamp effect);
- **21 - 40mA AC, 80 - 160mA DC** - total loss of control of affected muscles;
- **40 - 100mA AC, 160 - 300mA DC** - breathing blocked and if contact is prolonged, may cause collapse, unconsciousness and death,

because of the paralysis of respiratory muscles (when they are paralyzed for more than 3 or 4 minutes, they do not come back to function), and

- **Up to 100mA AC, 300mA DC up -** can cause immediate death. Occurs the stoppage of the heart, circulation ceases and all parties of the body (including the brain) no longer receive oxygen.

As noted, AC is more dangerous than DC. Depending on the state of the human body, voltages above 20VAC can bring problems. To have the same problems with DC, we would have to have a DC voltage greater than 80V.

The severity of the electric current depends a lot on the path through the body. A relatively high current can pass from one leg to another, without causing major problems, namely only burns in contact points.

The same current, passing between the arm and a leg, or between the arms, can cause death. For this reason, there are electronic technicians or electricity technicians that sensibly use a glove in the hand less skilled, leaving free the more skillful hand.

If we do not use gloves, when we touch at some point energized, it is advisable to use only the hand more well trained (if possible), keeping the other on the back of the body.

3) **Static Electricity -** It is a phenomenon that occurs with many people, but it is difficult to understand it. Its most common manifestation is the discharge experienced between our hands and a metal handle of a door.

It has been demonstrated that the electric load that rests on the human body can lead it to a potential of 50.000V (Ref. 1). This potential is enough to make a spark to jump through the air into an object under a lower potential. The energy available in this spark can easily ignite various solvent vapors.

On average, it is considered that the human body has a capacitance of 10^{-12}F (or 10 μμF).

Using the expression of the energy of a capacitor:

$$E = CV^2/2 \text{ J (joules)} \qquad (2)$$

Where E is the energy, C is the capacitance and V the potential (or voltage) of the capacitor.

Using the above values of $C = 10^{-12}$F and V = 50kV, $E \cong 1.3 \times 10^{-3}$J.

Now, compare with the ignition energy of some liquids shown in table 1.

Table 1 –Ignition Energy of Gases and Liquids

Gas or Liquid	Minimum Ignition Energy (J)
Hydrogen	$0{,}00002 = 2{,}0 \times 10^{-5}$
Ether	$0{,}00045 = 4{,}5 \times 10^{-4}$
Acetone	$0{,}00060 = 6{,}0 \times 10^{-4}$
Alcohol	$0.00065 = 6{,}5 \times 10^{-4}$
Gasoline	$0{,}00100 = 1{,}0 \times 10^{-3}$

We can understand that, at a minimum, we should be cautious in fuel stations.

In microelectronics, there is a concern with the destruction of chips (integrated circuits) by sparks from static electricity. The voltage which produces the spark that can destroy a chip is in the range 50/100V. This order of voltages can be generated when we pack or unpack a chip.

And now comes the most important. When two non-conductive materials come in contact and have a relative motion, can be generated static electricity. This is the case, for example, of a fluid in a pipe. If the liquid is flammable, you run the risk of ignition, and then an explosion. Rub in plastic material also generates static electricity, and how it generates!

Why a person charged with 50kV does not die when one discharge occurs from him to another body at lower potential?

To answer this question, we must report to the part of physics called Electrostatics.

It is known that a body in electrostatic balance has its entire electric load on the body surface. The electric field at the body surface is perpendicular to the body at each point of the same. That is why the electric load remains static.

In this way, the human body in electrostatic balance has your entire load on the surface, with all his points with the same potential. When a charged person touches a point with smaller potential (say the Earth), the current goes instantaneously to that point, but follows the body surface because it is the easiest path.