PRESLHY

Electrostatic ignition hazards

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Pre-normative REsearch for Safe use of Liquid HYdrogen

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Air Liquide

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Static electricity … Hazardous situation…

- Static electricity occurs commonly in industry and daily life. Many of the effects are harmless and either pass completely unnoticed or are simply a nuisance, but static electricity can also give rise to a hazardous situation.

- Hazards caused by electrostatic charge include :
  a. ignition and / or explosion of flammable atmospheres;
  b. electrostatic shock in combination with another hazard (e.g. fall, trip) ;
  c. electrostatic shock giving rise to injury or death;
  d. damage to electronics devices;
  e. breakdown when handling explosives and electro-explosive devices.

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Static electricity … Accidental situations…

Ignition source in the process industry

- Electrostatic discharge ‘ESD’ account for about **10 % of industrial gas, vapor or dust explosion ignition;**

- **Dynamic processes** (flow of liquid or solid materials) hazardous situation associated particularly to process (pneumatic conveyor, mixing and grinding vessel, dust collectors, silos, Big-Bag...);

- The **operator** itself without adequate ‘Protective Personal Equipment’ can be the source of ignition and is therefore likely to be trapped inside the explosion;

- **Various types of ESD** depending on the nature of material capable of retaining a significant electrostatic charge and configuration (brush discharge, spark discharge, propagating brush discharge...);

Static electricity … Charging mechanisms

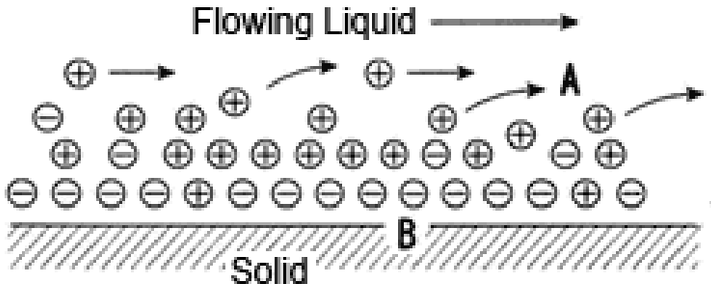
- Static electricity is generated by :

  a. the contact and separation of solids e.g. the movement of conveyor belts, plastics film, etc. over rollers, the movement of a person;
  b. the flow of liquids or powders, and the production of sprays;
  c. induction phenomena, i.e. objects reach high potential or become charged due to being in an electric field.

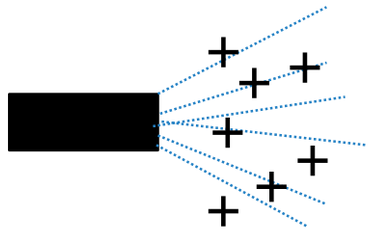
=> The accumulation of electrostatic charge can give rise to hazards and problems in a wide range of industries and working environments, and to ignition and explosion hazards in particular with hydrogen.

Charging mechanisms

- Liquids can become electrostatically charged when:
  - They move relative to contacting solids
  - There are tow or more immiscible liquid phases and there is movement
  - They are sprayed producing highly charged mist or spray



Static Electricity Generated by Flowing Liquid



Static Electricity Generated by a Spray

Charge accumulation in a liquide

- The level of charge accumulation in a liquid is dependent its electrical conductivity and dielectric constant
- Hazardous levels of charge accumulation are most commonly associated with liquids of **low conductivity**

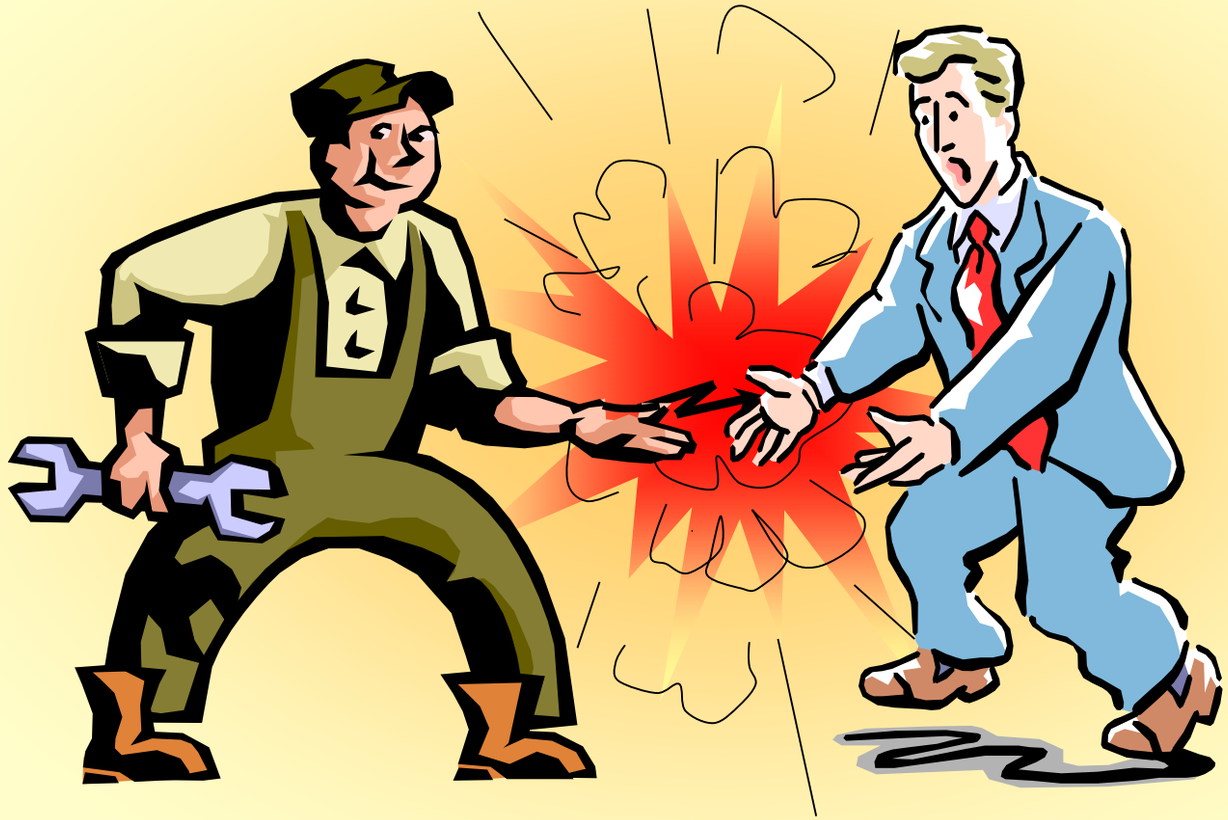
> **10.2.5. Electrical Conductivity**
>
> The electrical conductivity of liquid hydrogen has been measured by Willis,[5] who found typical resistivities in the vicinity of 10^{19} Ω·cm. However, the data

=> Liquid hydrogen at low temperature (not so at very high pressure) has a very low conductivity

Various types of discharges :

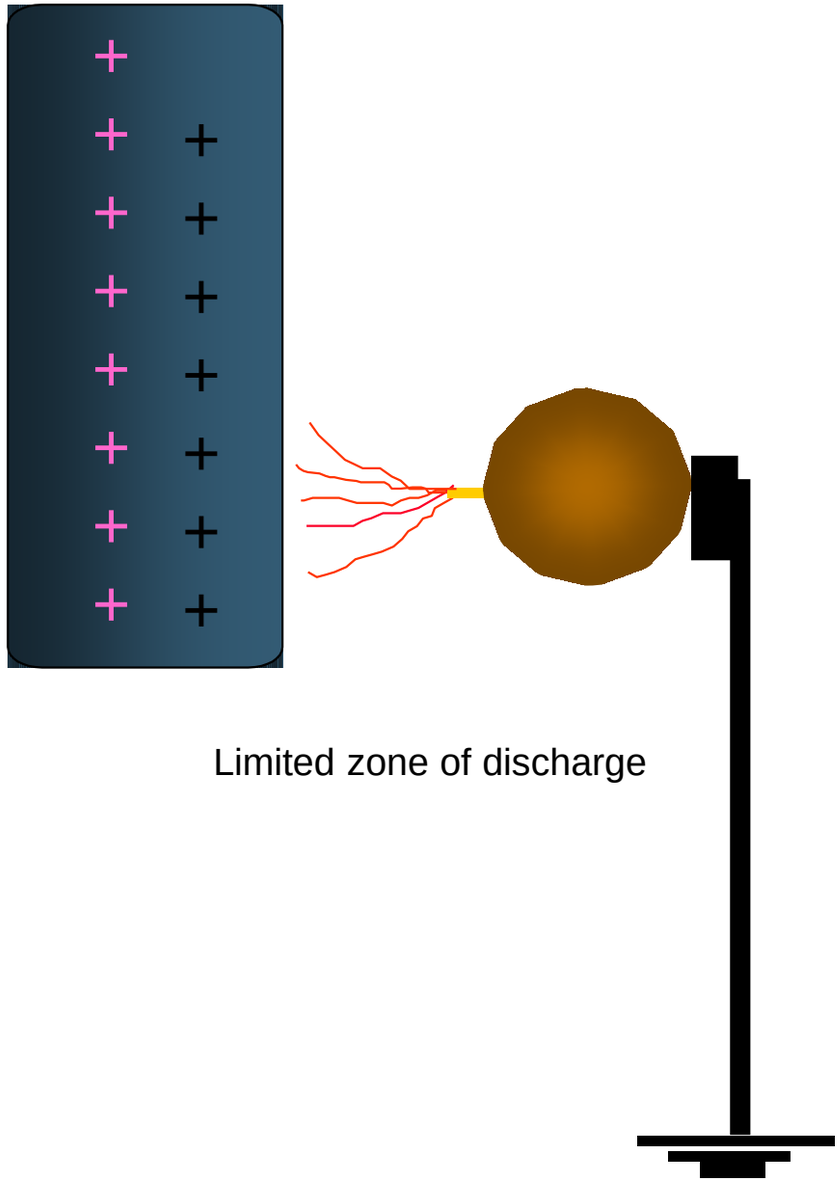
May cause painful ‘electric shocks’ to person at the office or at the workstation

- **Reaction : unpleasant effects of a handshake**



Various types of incendive discharges :

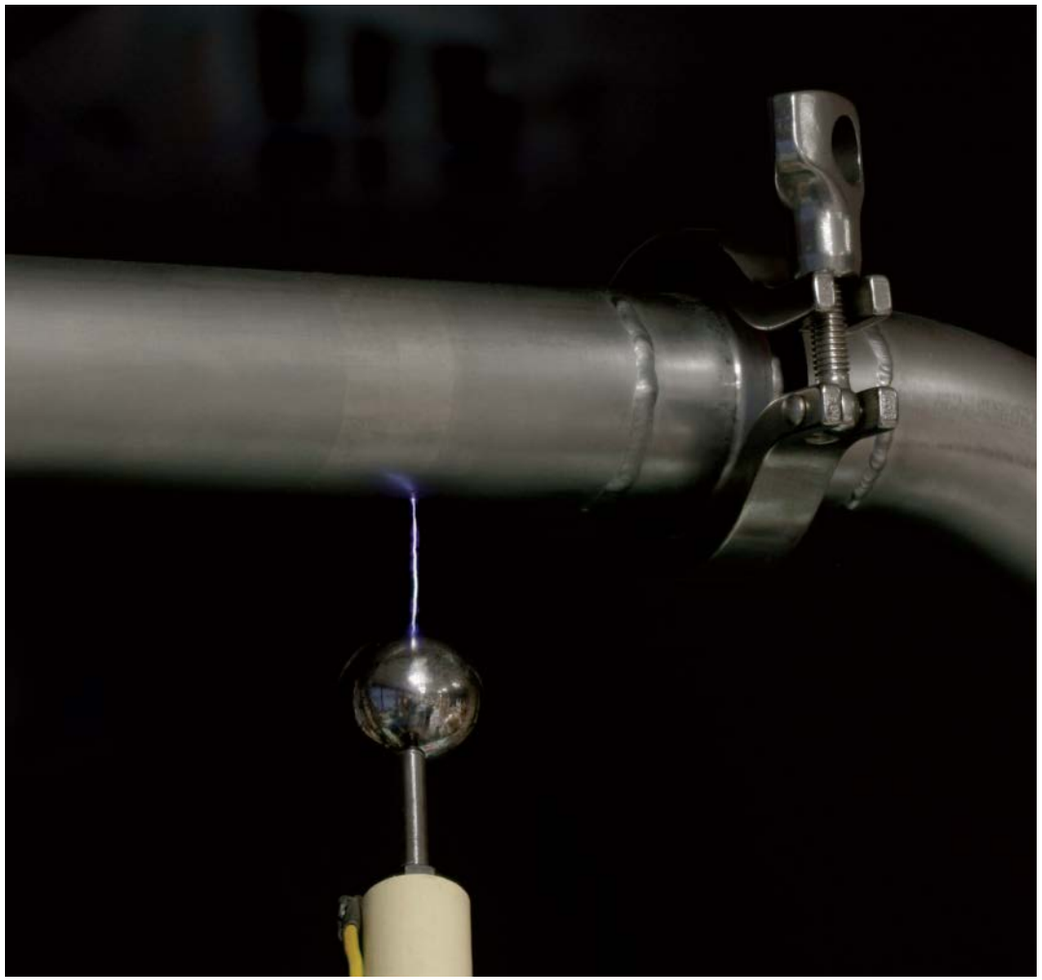
Charging of external insulating material surfaces by rubbing could give **brush discharges**



This type of discharge occur when rounded earthed conductors are moved towards charged insulating objects

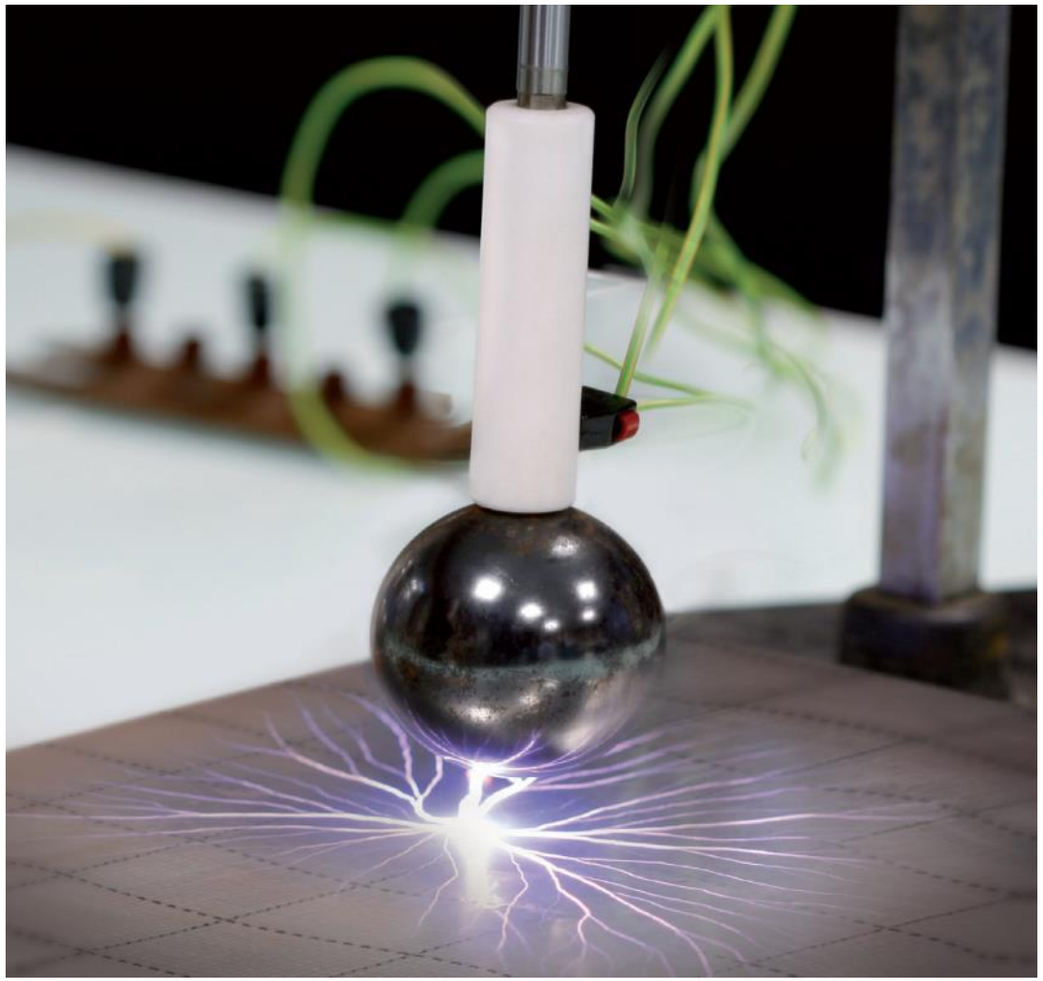
Various types of incendive discharges :

Spark discharges can occur when charge builds up on two insulated conductors



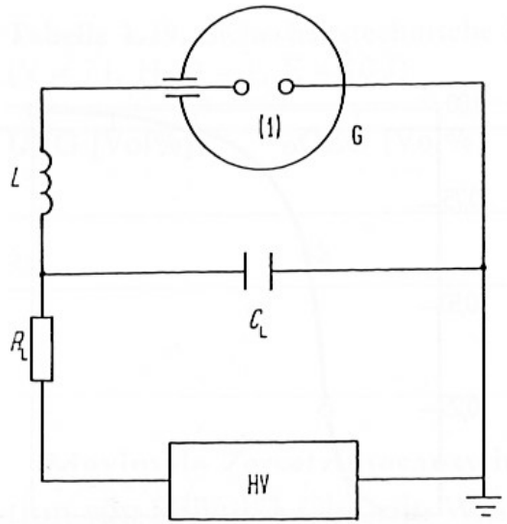
Various types of incendive discharges :

Propagating brush discharge can be generated on an insulating sheet or layer with earthed metal backing

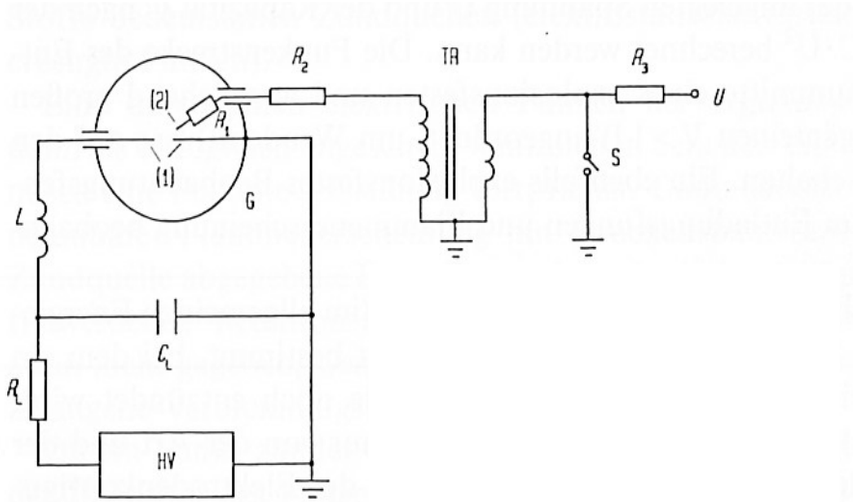


Minimum ignition energy

- Today there is no standard to measure the MIE, so multiple setups exists today



2 electrodes system



3 electrodes system

- The energy of the spark can be estimated by the calculation of the stored energy of the capacitors of the total capacity C:

$$E=1/2*C*U^2$$

Remarks

- What kind of discharge represent results realistic hazardous conditions
- Turbulence and pressure has an influence on the MIE like shown in previews research’s
- Regarding accidental liquid hydrogen release the formation of solid particles of nitrogen/oxygen/water could influence the charge mechanism
- For the identification of static electricity hazards in relationship with accidental LH2 release the measurement of resistances chart to mass and or space charge densities may be helful (cf. IEC/TS 60079-32-1 Explosive atmospheres – Part 32-1: Electrostatic hazards, guidance)