Motor Vehicle Fire Research Institute
Awarded Contracts

Title: Conductivity Measurements for New Engine Compartment Fluids

Contractor: Chilworth Technology, Inc.

Duration: March 1, 2004 – May 31, 2004

Purpose:

The purpose of this program is to determine the conductivity of various engine compartment fluids found in a new automobile. Eight liquid samples were identified and provided by MVFRI. These samples are identified in the following table; with the addition of four samples in which two are a mixture of hydrocarbons (sample 9: regular gasoline and sample 10: diesel fuel) and the other two samples are each mixed with 50% sample and 50% mixture of water (sample 11: ethylene glycol and sample 12: propylene glycol).

1. Motor Oil (Quaker State) – SAE 5W30
2. Synthetic Motor Oil (Mobil 1) – SAE 5W30
3. Power Steering Fluid (Valvoline) – Synpower
4. Automatic Transmission Fluid (Quaker State) – Dextron III/Mercon
5. Brake fluid (Prestone) – DOT 3
6. Antifreeze (Prestone) – Ethylene Glycol 100%
7. Antifreeze (Sierra) – Propylene Glycol 100%
8. Windshield washing fluid (All Weather) – Winter
9. Regular Unleaded Gasoline
10. Diesel Fuel
11. Diluted (50% water) Antifreeze (Prestone) – Ethylene Glycol 100%
12. Diluted (50% water) Antifreeze (Sierra) – Propylene Glycol 100%

When a voltage (V) is applied to a material, charge flows creating an electric current (I). The ratio between the voltage and the current is called the resistance (R). This relationship between voltage, current, and resistance is given by Ohm's Law:

$$V = I \times R \qquad \text{[Equation 1]}$$

Resistance provides an indication of the relative ease or difficulty with which charge flows through a material. However, the resistance of a material is dependent on its size and geometry, among other factors. For example, it becomes more difficult for charge to flow through a material as its cross-sectional area decreases or its length increases. Consequently, it was necessary to derive measures that permit comparisons between the resistances of various materials independent of size and geometry. One such measure is conductivity.

The conductivity of a liquid is defined as the reciprocal of the electrical resistance at unit length and unit cross-sectional area through the liquid. This relationship may be expressed as follows:

$$\delta = (1/R) \times k \qquad \text{[Equation 2]}$$

where,

δ = conductivity (S/m)
V = test voltage (volts)
I = current between electrodes (amps)
k = measurement cell geometrical constant

Hence,

$$\delta = (I/V) \times k \qquad \text{[Equation 3]}$$

Conductivity is a valuable measure as it fulfills the need for a comparative measure of the conductive or insulating character of materials. Since it is based on unit length and unit cross-sectional area, conductivity is independent of sample size and geometry and thus is a property of each material. Conductivity is measured in units of siemens per meter (S/m). However, given the magnitude of the siemen, conductivity is commonly reported in picosiemens per meter (pS/m). [1 pS = 1 x 10^{-12}S]

It is important to know whether a liquid is electrically-insulating or conductive from a materials handling perspective. Insulating liquids are prone to generation and accumulation of electrostatic charge and thus pose special handling problems. When liquids flow or are otherwise processed, they may become charged. In many cases, the charge on conductive liquids can be controlled or eliminated by handling such liquids in grounded vessels, equipment, and conveyances. In contrast, insulating liquids may remain charged even when handled in grounded equipment. Accumulated charge can lead to electrostatic discharges capable of igniting flammable atmospheres.

Chilworth Technology, Inc., performs liquid conductivity testing in accordance with British Standard 5958, Code of Practice for the Control of Undesirable Static Electricity - Part 1 (1991) and ASTM D2624, Standard Test Method for Electrical Conductivity of Aviation and Distillate Fuels. The method involves the use a liquid conductivity cell. The cell consists of a pair of concentric cylindrical electrodes. The liquid sample to be tested is poured into the annular space between the electrodes and a known voltage is applied. The current through the cell is measured and the conductivity is calculated from the measured current, applied voltage, and cell constant using Equation 3 from above. Trials are repeated until a relatively constant conductivity value is obtained. The test system is checked (validated) before, during, and after testing by measuring the conductivity of heptane (certified grade) -- a known insulating liquid. When the liquid sample is conductive a BM-10 megohmmeter is used to measure the resistance.

The conductivity for the listed fluid materials will be determined and reported. A final report will be provided, which summarizes the findings.