Motor Vehicle Fire Research Institute
Awarded Contracts

Title: Testing of Carbon Arc Behavior of Automotive Thermoplastics

Contractor: Underwriter's Laboratories

Duration: October 21, 2002 – March 21, 2003

Funding: Jointly Funded by USCAR (75%) and MVFRI (25%)

Purpose:

The automotive industry is evolving automobile designs using greater electrification of systems and components previously mechanically operated. The resulting demands on electrical systems may require upgrading from the traditional 12v DC battery supply to a 36v DC battery supply with a nominal 42v DC charging circuit. The potential of a fire hazard has been identified as a concern resulting from the inappropriate selection of thermoplastic materials used for automotive switches, electrical connectors, etc. when operating at increased DC voltage levels. One specific concern is the DC arc track properties of thermoplastic materials. As opposed to an AC arc, once established, a DC arc tends to be self-sustaining.

In order to study the risk of a potential fire hazard associated with the increased DC voltages, this research project will study the arc track properties of plastics materials when subjected to DC voltages ranging from 12v DC - 150v DC**.** It is important that a standardized, reliable, and reproducible arc tracking test method be developed for the higher DC voltage automotive applications. An existing method for evaluating arc track performance of plastic materials is the Comparative Tracking Index (CTI) described in UL 746A and using the apparatus described in ASTM D 3638 Standard Test Method for Comparative Tracking Index of Electrical Insulating Materials. The traditional CTI test is performed at AC voltages up to 600v AC. In order to develop a meaningful test to evaluate plastic materials for automotive applications, modifications to an AC tester will be necessary to operate at DC voltages.

The primary objective is to optimize the DC-CTI test design through extensive experimentation on a variety of materials. Once an acceptable design is determined, a series of evaluation trials will be conducted using a sufficient number of materials obtained from a variety of plastics manufacturers to confirm adequate precision, repeatability, and accuracy.

The project has been divided into six Tasks with associated Deliverables:

- **Task 1 – Situation Analysis**

  Literature, standards developed by others, and previous research work will be reviewed for relevant information concerning the proposed DC-CTI test.

- **Task 2 – Modification & Review of Equipment**

  The equipment used for AC-CTI testing will be modified to permit DC-CTI testing. Testing with the following modifications will be explored, along with the development of the rationale for each change:

- The AC voltage supply to the electrodes will be replaced with a DC voltage power supply.
- The maximum current that the power supply is capable of delivering during a CTI test will be limited to 20 A.
- The reagent fluid will be changed from a 0.1% Ammonium Chloride to a 5% Sodium Chloride solution.
- Copper electrodes will be used in place of platinum electrodes.
- Ignition of the plastic material under test will signify end-of-test. Optical sensors (IR & UV) will monitor ignition.

- **Task 3 – Comparative Testing**

  Twenty-five (25) thermoplastic materials/molded components will be provided by USCAR for testing. For each material, a DC-CTI test will be performed starting at a maximum 150v DC and working (in 5 increments) down to a minimum of 12v DC or until 50 drops of the 5% NaCl reagent solution no longer produces an arc track. The voltage levels will be 150, 100, 60, 42 and 12v DC. For each test, the number of drops (maximum 50) and the time to cause ignition will be recorded. Some thermoplastic materials may be filled with randomly oriented or axis oriented glass filler materials. Using a sampling of axis oriented glass filled thermoplastic materials, DC-CTI testing will be performed to evaluate the effects of orientation of the material with respect to the electrodes. The CTI Test will be performed parallel to the grain, perpendicular to the grain, and at a 45 degree angle to the grain to obtain the most adverse test result.

- **Task 4 – Additional Testing**

  From the comparative testing, five (5) materials will be selected for further study. The DC-CTI test will be repeated at a voltage of 60v DC and a maximum contaminant level of 500 drops. The DC-CTI tester will be instrumented to capture and save the voltage and current waveforms.

- **Task 5 – Data Analysis**

  Following completion of the above testing, the data will be analyzed and summarized. Included will be a determination if further areas of exploratory research testing may be required. Such testing may be suggested as part of a Phase 2 program.

- **Task 6 – Final Report**

  From the information obtained in the above tasks, a summary report will be prepared that will include:

  - Documentation of the situation analysis
  - A detailed description and analysis of the DC-CTI test equipment modifications including suggestions for further improvements. A draft equipment and instrumentation specification will be produced.
  - A description of the test procedure.
  - A record of the results obtained.
  - A discussion of any test result anomalies or other test difficulties encountered.