# Motor Vehicle Fire Research Institute
# Awarded Contracts

**Title:** Toxicity Evaluation of Motor Vehicle Components

**Contractor:** Southwest Research Institute

**Duration:** November 12, 2002 – June 12, 2003

**Purpose:**

Combustible materials produce smoke atmospheres that are toxic, contributing to physical incapacitation, loss of motor coordination, faulty judgment, disorientation, restricted vision, and panic, all of which inhibit or prevent egress from a burning vehicle. In support of an ongoing research program for NHTSA (SwRI Project No. 01.05804) to compare fire properties of automotive materials, SwRI is currently selecting and procuring 18 exterior automotive parts, approximately nine each from two cars that were previously tested in full-scale in the Factory Mutual fire products collector. However, the current program focuses on thermal properties such as ignition, heat release, and smoke production data, while the work to be performed for the Motor Vehicle Fire Research Institute (MVFRI) deals with the toxicity of the smoke evolved from those materials during combustion.

SwRI's Fourier transform infrared (FTIR) spectrometer is calibrated at a spectral resolution of 0.5 cm-1 for seven standard gas species commonly found in combustion products. Irritants such as the halogen gases (hydrogen chloride, hydrogen fluoride, and hydrogen bromide) and nitric oxide are generally not fatal during inhalation, but cause post exposure fatality due to pulmonary damage. Asphyxiants such as carbon monoxide and hydrogen cyanide cause loss of consciousness and possibly death. Other compounds such as sulfur dioxide can lead to death at sufficiently high doses. Because of the need for rapid egress after a car crash, engine fires leading to smoke inhalation by trapped passengers greatly reduce the amount of time rescue crews may have to be effective. All proposed tasks will use FTIR spectrometry on each run for toxicity analyses.

The project has been divided into three Tasks with associated Deliverables.

- **Task 1 – Small-Scale Calorimetry Measurements**

  As part of the NHTSA program, the 18 materials will be subjected to a range of exposure conditions in the Cone calorimeter, for a total of 108 separate test runs. Samples (100 x 100 mm) are exposed to the radiant flux of an electric conically shaped heater. While the thermal tests are being conducted, SwRI proposes to supplement tests with the FTIR spectrometer for real-time analysis and quantification of smoke gases.

  Mass loss data collected during the Cone tests will be correlated with the concentration data as yields of gas species produced per gram of mass lost. Data will be reported as milligrams per gram. Additionally, aggregate toxicity indices will be reported by combining data as a concentration–time product that results in incapacitation of 50% of an exposed population (FAA and Purser models), defined as the Fractional Effective Dose (FED). The FED values will provide the likelihood that a person exposed to the gas mixture in the exhaust duct would become incapacitated or die, and results can be used to rank-order and compare materials.

- **Task 2 – IMO Smoke Chamber Measurements**

  After Task 1 is completed, data from the calorimetry tests will be reviewed to select materials with the worst performance with regard to toxicity, the best performance, and one material in the middle. SwRI will recommend material selection to NHTSA and final selection will be made by MVFRI.

  The modified NBS smoke chamber prescribed for use by the International Maritime Organization (IMO) will be used in Task 2 to help establish acceptance criteria based on the Cone calorimeter measurements that are consistent with toxicity requirements used in maritime transportation. Duplicate tests on three materials selected will be conducted at each of the three exposure conditions typically conducted in accordance with IMO procedures—25 kW/m2 with and without a pilot flame, and 50 kW/m2 without a pilot flame. The IMO smoke and toxicity test apparatus uses a conical heater similar to the one used in the Cone calorimeter, and exposes a square sample (75 x 75 mm) in the horizontal orientation as well. However, while the Cone calorimeter is a dynamic system, with a constant influx of surrounding air, the IMO smoke chamber is a static system, allowing the build-up of combustion products over time. The FTIR spectrometer will be linked to the smoke chamber in a similar manner as with the Cone. As with the Cone calorimetry data, results will be presented as concentration in ppm; yields as milligrams of gas produced per gram of automotive material consumed; and as FED curves.

- **Task 3 – ASTM E 662 Smoke Chamber Measurements**

  While similar in nature to Task 2, the apparatus and therefore the scope of work in Task 3 will provide data relative to U.S. railcar and international aerospace standards, as opposed to maritime evaluations.

  Duplicate tests on the three selected materials will be conducted at two exposure conditions typically conducted in accordance with ASTM E 662 procedures—25 kW/m2 with and without a pilot flame. The E 662 smoke test apparatus uses a conical heater similar to the one used in both the IMO smoke chamber and the Cone calorimeter. However, the heater is vertically oriented, as is the 75 x 75-mm sample. Additionally, while the other two tests utilize a single pilot flame situated horizontally over the sample in the gas effluent stream, the ASTM E 662 chamber uses six "multi-flamelet" burners. Two burners impinge on the sample, while the other four are positioned vertically in the gas stream. The FTIR spectrometer will be linked to the smoke chamber just as in Task 2.

  As in Task 1 and 2, results will be presented as concentration in ppm; yields as milligrams of gas produced per gram of automotive material consumed; and as FED curves. However, additional analyses will be conducted on related, published pass/fail criteria, such as those presented by the Department of Transportation's Federal Railroad Administration, Boeing Corporation, Bombardier Transportation Group, and Airbus Industrie.