

SAE Government Industry Meeting | January 25-27, 2017

Test Procedures for Evaluating Flammability of Interior Materials

Barbara C. Hennessey
Vehicle Safety Research

NHTSA





OUTLINE

- Background
- Objectives /Goals
- Work Plan
- Test Facilities
- Project Deliverables and Schedule



PROJECT BACKGROUND – FMVSS No. 302

- In 1969, NHTSA determined the need to address fire safety in vehicle interiors, as information from the NFPA estimated over 400K vehicle fires per year, 25% originating in the interior.
- FMVSS No. 302, Flammability of Interior Materials, was adopted in 1971. The standard is based on a recommended practice developed by SAE. Specifies a horizontal burn rate of not more than 102 mm/minute on materials within 13mm of the passenger compartment interior.
- The objective was to establish a reasonably low maximum burn rate for interior materials to reduce severity and frequency of burn injuries and increase occupant evacuation time.
- Flammability requirements for car seats was required since 1981.
- While some of the other transportation industry standards (i.e. for aircraft and rail) have evolved over time with the use of more modern material flammability techniques, FMVSS No. 302 has remained essentially the same since 1972.



PROJECT BACKGROUND

Frequency, Outcome of Vehicle Fires

- Highway vehicle fires accounted for 14 percent of fires responded to by fire departments across the nation.
- The U.S. Fire Administration (USFA) using the National Fire Incident Reporting System (NFIRS) for the years 2008 - 2010, estimated that on average, **194,000** vehicle fires occurred in the U.S. each year.
- Vehicle fires result in about **300 fatalities**, 1,250 injuries and \$1.1 billion of property loss annually.
- USFA estimates an annual average of **20 fatalities of children** 0 - 5 years old as a result of passenger vehicle fires.



PROJECT BACKGROUND

Origin of Vehicle Fires

Origin of Vehicle Fires:

- 61% of vehicle fires originate in the engine compartment
- 15% originate in the passenger compartment
- 4% originate in the cargo/trunk area
- 1.7% originate in the fuel tank/fuel line
- 18% originate in other parts of the vehicle (unspecified).

Three Most Common Heat Sources for Vehicle Fires:

- 62% from powered equipment
- 12% from hot or smoldering objects like over heated tires/bearings
- 9% from open flame or smoking materials like cigarettes and matches

Crash Induced Fires:

- 4% of vehicle fires involve crash
- 57% of fatal fires involve collision contributing to ignition



PROJECT OBJECTIVES AND GOALS

- The objective of this research effort is to develop improved flammability tests for FMVSS No. 302 to make it a more robust, objective standard.
- The goal is to improve repeatability and reproducibility of procedures and results to assess flammability of interior materials
- The outcome of the program may support adoption of procedures and performance criteria that demonstrate improved relevance to the current requirements of FMVSS No. 302.



PROJECT TOPIC AREAS

- Identify the cause, origin, propagation paths, and relative frequency of real world vehicle fires by vehicle type.
- Assess the objectivity/relevance of the FMVSS No. 302 procedures compared with the origin/propagation of passenger compartment fires observed in the reviewed vehicle fire cases and literature.
- Identify materials for flammability testing (based on the information from the generalized fire cause and origin task) in representative vehicle types, including light duty passenger vehicles, motorcoaches, school buses, and child seats.
- Identify existing testing protocols that appear to match the needs for objective, repeatable and reproducible material flammability evaluation for comparison testing with the FMVSS No. 302 test and performance requirements.
- Test the materials under identified alternative methods found to be relevant to the dominant origin and propagation mechanisms of passenger compartment fires.
- Determine test procedures and performance criteria that demonstrate improved repeatability over current FMVSS No. 302 testing, and assess their equivalence to FMVSS No. 302 performance.



WORK PLAN

Task 1: Literature and Test Method Review

- 1.1 Material flammability test methods
- 1.2 Cause, origin, propagation of vehicle fires
- 1.3 Characteristics of passenger compartment fires and materials involved.



WORK PLAN

Task 2: Testing and Reporting

2.1 Material Procurement

- NHTSA to provide samples, SwRI to provide sample prep

2.2 Protocol Evaluation Testing

2.3 Data Analysis of Comparison Testing

2.4 Final Protocol Testing and Evaluation

2.5 Document Final Testing Protocols and Procedures



WORK PLAN

1.1: Material Flammability Test Methods

- Final literature review will ensure that all relevant standards, specifications, and research reports are considered to evaluate the performance of materials for preventing ignition or delaying propagation of a vehicle interior fire through the passenger compartment.
- Particular attention will be given to test methods from the perspective of relevance, objectivity (repeatable and reproducible), and equivalency.
- 25 test methods were reviewed and considered for testing. Preliminary assessment resulted in 4 primary test methods as well as a supplementary method specific to school buses.



WORK PLAN

1.1: Material Flammability Test Methods

Test Method Designation	Title/Description
49 CFR 571.302	FMVSS No. 302-Horizontal burn rate test of 4x14 inch sample using a Bunsen burner – similar to ASTM D5132, SAE J369, ECE R.118 - Annex 6.
ASTM D3801-10	Standard test method for measuring the comparative burning characteristics of solid plastics in a vertical position. Similar to ECE R.118 –Annex 8, UL 94, and 14CFR 25 – Appendix F.
ASTM E1354-16a	Standard cone calorimeter test: Cone calorimeter test has an advantage over Bunsen burner type tests because the heat release rate can be related to real world vehicle fire scenarios. Previous research has demonstrated repeatability. Test parameters can be tuned to make equivalent to FMVSS No. 302.
ASTM D7309-13	Standard test method for determining flammability characteristics of plastics and other solid materials using microscale combustion calorimetry. Useful in testing small and non-standard size material.
ASTM E2574 / E2574M - 12a	Standard test method for fire testing of school bus seat assemblies. Maybe used for bus materials.



WORK PLAN

Task 1.2: Cause, Origin and Propagation – Data

The objective in this task will be to characterize the cause and origins of passenger compartment fires. Attention will also be given to car seats, school buses, and motorcoaches to examine how they differ from passenger cars and light trucks. The following information sources will be used for this purpose:

- NFIRS
- NASS-CDS for crash induced fire information
- Discussion with school bus manufacturers, carriers and school districts
- Discussion with motorcoach manufacturers and carriers
- Discussion with Consumer Product Safety Commission and manufacturers of child car seats
- Office of Defect Investigation cases
- NTSB/NTRB cases
- CPSC cases
- NHTSA, GM, MVFRI and other vehicle testing results



WORK PLAN

Task 1.3: Major Fire Types and Materials

- The frequency of passenger compartment fires by make, model and year will be identified utilizing NFIRS. Confirmation of fire incidence by vehicle type will be confirmed utilizing GES and FARS information to check the relative frequencies observed in NFIRS.
- The frequency of child seat involvements will be determined through use of NFIRS, GES, and NASS-CDS.
- A characterization of the materials types, volumes and distribution by vehicle type will be determined through inspection, tear down, or part diagrams for representative vehicles.
 - This will support virtual evaluation of the effects of changes in these materials.
- Propagation paths, compartment openings and general geometry will be obtained from existing representative vehicle models.
- An assessment of the principal characteristics of materials and fires will be made and compared with existing material flammability testing protocols to establish suitability for relevance, reproducibility, objectivity and equivalency.



WORK PLAN – Testing and Reporting

2.1: Material Procurement (NHTSA)

- Passenger Vehicle Interior - 2 -3 late model passenger vehicles
Seats, flooring, headliner, seat belt,
door panel, sun visor
- School Bus Seats
Blue Bird, Trans Tech, Starcraft
- Motorcoach Interior
2014 Prevost X3-45, Seats, floor
covering, window curtains, luggage
racks/doors
- Child Seats
Qty. 7 Britax Parkway "SG"
Qty. 4 Chicco Key Fit
Qty. 3 Harmony Dreamtime
Qty. 2 Evenflo Symphony
Qty. 2 Peg-Perego Primo Viaggio
Qty. 2 Baby Trend Hybrid 3-in-1





WORK PLAN

2.2: Protocol Evaluation Testing

The test program will evaluate the following:

- Sample selection and specimen size of interior passenger compartment material for testing purpose.
- Composite materials (layers of different material) tested as a single unit and tested separately.
- The relevance of the tests and test results to real world passenger compartment vehicle fires.
- Repeatability of the various test methods.
- Equivalence of different test methods (test parameters and performance criteria), including FMVSS No. 302.



WORK PLAN

Task 2.2: Protocol Evaluation Testing

- Consists of 300-400 experiments spread across the various test methods included in the final work plan.
- The final selected methods for comparison and estimated number of tests were allocated as follows:
 - FMVSS 302 Horizontal Burn Test Testing (~50 tests)
 - ASTM D3801 Comparative Burning of Solid Plastics Testing (~50 tests)
 - ASTM 1354 Cone Calorimeter Testing (~100 tests)
 - ASTM 7309 -13Microscale Combustion Calorimetry Testing (~100 tests)
 - ASTM E2574 School Bus Seat Assemblies (~50 tests)
- Based on the outcome of this testing, protocols details may be modified and additional tests could be identified for consideration.
- Documentation of the suitability of each test method to improve repeatability, and relevance to fire performance of the subsystem/material will be provided.



WORK PLAN

Task 2.3: Data Analysis of Comparison Testing

- The test results will be compiled and analyzed for relationships between the various test methods and their applicability to real fire scenarios found in the review tasks.
- In addition, based on the results of the initial testing, the tests of further interest will be assessed for their repeatability. Statistical methods will be used to establish variability between tests. To the extent there is an undesirable amount of variability, the source of the variability will be evaluated and identified.

Material Description	Passenger Vehicles	Motorcoaches	School Buses	Subtotals
Seat Padding	13	13	26	52
Seat Cover	13	13	26	52
Seat Assembly	6	6	24	36
Dashboard	19	19		38
Headliner	19	19		38
Floor Covering	19	19		38
Glovebox	19	19		38
Door Panel	19	19		38
Window Curtains		19		19
Child Seat 1 - Cover	13			13
Child Seat 1 - Substrate	13			13
Child Seat 1 - Assembly	6			6
Child Seat 2 - Cover	13			13
Child Seat 2 - Substrate	13			13
Child Seat 2 - Assembly	6			6
Subtotals:	191	146	76	413



WORK PLAN

Task 2.4: Example of Final Protocol Testing and Evaluation (1 of 2)

Test replicate information and material requirements
 School bus test matrix (number of tests)

Material Description	FMVSS 302	ASTM D3801	ASTM E1354	ASTM D7309	ASTM E2574	Subtotals
Seat Padding	10	10	0	6	0	26
Seat Cover	10	10	0	6	0	26
Seat Assembly	0	0	12	0	12	24
Subtotals:	20	20	12	12	12	76

School bus test matrix (material requirements)

Material Description	FMVSS 302 (in ²)	ASTM D3801 (in ²)	ASTM E1354 (in ²)	ASTM D7309 (mg)	ASTM E2574 (full seats)
Seat Padding	560	25	0	60	0
Seat Cover	560	25	0	60	0
Seat Assembly	0	0	192	0	12
Subtotals:	1120	50	192	120	12



WORK PLAN

Task 2.4: Example of Final Protocol Testing and Evaluation (2 of 2)

Passenger Vehicle Test Matrix (Number of Test Replicates)

Material Description	FMVSS 302	ASTM D3801	ASTM E1354	ASTM D7309	Subtotals
Seat Padding	5	5	0	3	13
Seat Cover	5	5	0	3	13
Seat Assembly	0	0	6	0	6
Dashboard	5	5	6	3	19
Headliner	5	5	6	3	19
Floor Covering	5	5	6	3	19
Glovebox	5	5	6	3	19
Door Panel	5	5	6	3	19
Child Seat 1 – Cover	5	5	0	3	13
Child Seat 1 – Substrate	5	5	0	3	13
Child Seat 1 – Assembly	0	0	6	0	6
Child Seat 2 – Cover	5	5	0	3	13
Child Seat 2 – Substrate	5	5	0	3	13
Child Seat 2 – Assembly	0	0	6	0	6
Subtotals:	55	55	48	33	191



WORK PLAN

Task 2.5: Document Final Testing Protocols and Procedures

- Detailed test procedures and performance criteria that improve upon repeatability, reproducibility and objectivity of FMVSS No. 302 will be created based on the analysis and testing results obtained.
- Standard forms, sampling criteria, data fields for self-certification of materials to test criteria will be created suitable for use in a manner similar to the representative NHTSA laboratory test procedures that exist for each FMVSS.

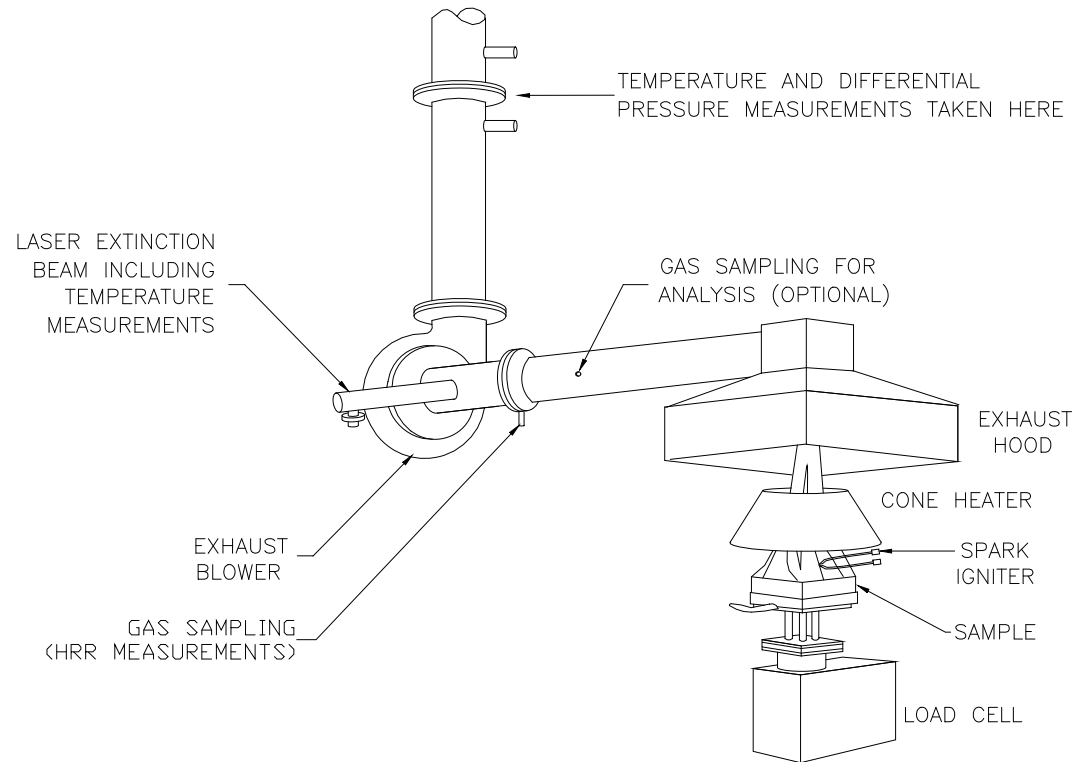


Test Facilities: SwRI

- Fire Technology Department (FTD)
- Chemistry and Chemical Engineering Division
- FTD is an internationally recognized center-of-excellence in performance assessment of materials and structures to the damaging effects of fire.
- FTD is ISO accredited and has the capability of performing over 200 different standard fire test procedures
- Includes standard tests on automotive materials and components.
- Subject matter expert advisory panel
- Friedman Research Corporation consultant

TEST FACILITIES (1 of 5)

- ASTM E1354
- Cone Calorimeter



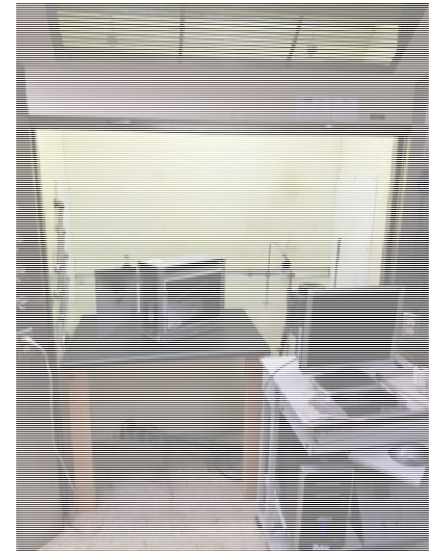
- ASTM D7309
- Microscale Combustion Calorimeter



TEST FACILITIES (2 of 5)

Small-Scale Fire Test Laboratory

SwRI's small-scale material flammability tests, including **FMVSS No. 302**, ASTM D5132 / SAE J369 / ISO 3795, ECE R118, 14 CFR 25, Appendix F., Part I (FAR25.853(a)), **UL 94**, NFPA 701, and many more are conducted in one of three different fume hoods in the FTD.



TEST FACILITIES (3 of 5)

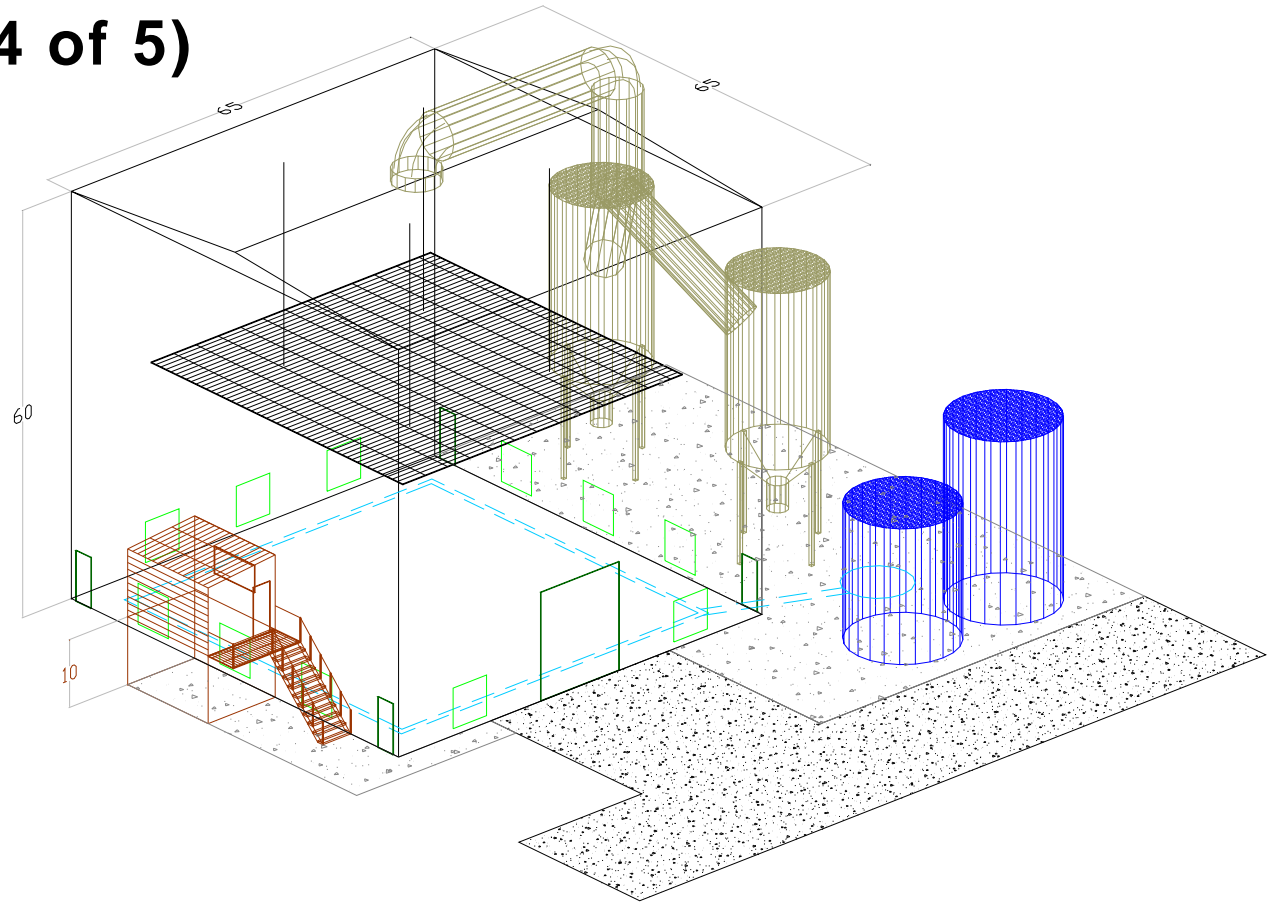
Large-Scale Calorimeter
Facility

ASTM E2574



TEST FACILITIES (4 of 5)

Large Scale Fire Engineering and Research Facility



TEST FACILITIES (5 of 5) - Off-site Test Facilities



Southwest Research Institute® Remote Test Site

The test site encompasses 1,800 acres, is fully high-fenced and is located in a remote area of rural Uvalde County, Texas, approximately 60 miles west of San Antonio. The site is privately owned and is leased to SwRI as needed. It is accessible by all-weather roads.

Facilities at the site include water, single phase power, heavy equipment backhoe and forklift, rest room and a 40 x 60 ft. storage shed.

SwRI fire technology specialists conducted numerous experiments for a Discovery Channel program to solve the mysteries surrounding the Hindenburg disaster.

SwRI performs hydrogen fuel tank testing at the remote site.

Fueled 7000 liter propane tank exposed to fire.



Project Deliverables and Schedules

Final Work Plan	December 2016
Quarterly Progress Reports	Q1-q4 Cy2017, Q1 Cy2018
Mid-program Status Briefing	September 2017
Draft Final Report	April 2018
Final Program Briefing	May 2018
Final Report	June 2018

