



# RESEARCH FOUNDATION

RESEARCH FOR THE NFPA MISSION

## REQUEST FOR PROPOSALS FOR FIRE TESTING CONTRACTOR

### Electric Vehicle Hazards in Parking Structures – Full-Scale Testing

8 June 2021

**Background:** The Fire Protection Research Foundation recently completed a Phase I project with Combustion Science and Engineering, Inc. (CSE) on “[Modern Vehicle Hazards in Parking Structures and Vehicle Carriers](#)” to document the current understanding of the fire hazard modern vehicles present to parking structures and marine vessels. The findings of the study indicated that the spread of fire between cars in a garage, especially from the initial to the second and third vehicles, is critical in determining the extent of the fire and the ability of the fire department to successfully control and extinguish it. Full-scale testing with a range of configurations was identified as a necessary next step to evaluate the spread dynamics and critical parameters that influence electric vehicle fires.

Our next step is to continue working with CSE to implement a follow-up project to fill some of the identified knowledge gaps – namely quantifying the fire spread hazards of electric vehicles in parking garages settings and the impact of fire sprinklers. The Fire Protection Research Foundation is moving forward on the project – the full scope is provided [here](#). This RFP is to specifically seek proposals from organizations with large-scale fire testing capabilities who can accommodate the proposed vehicle fire tests specified in this RFP.

**Overarching Research Goal:** The goal of this project is to quantify the fire hazard and spread characteristics of electric vehicles in parking structures to inform fire protection requirements. This effort builds upon the earlier Phase I literature study and specifically addresses the planning, implementing, collecting, and analyzing fire test data, with a specific focus on the use of automatic sprinklers as the primary fire protection approach.

#### **Involved Parties:**

- **Fire Protection Research Foundation (FPRF)** is the administrative lead for this project. Both the engineering contractor and the testing contractor shall report to FPRF.
- **Engineering Contractor** – Combustion Science and Engineering, Inc. was selected through an open RFP process to be the engineering contractor for Phase I of the “Modern Vehicle Hazards in Parking Garages and Vehicle Carriers” project. They will be continuing this work to further assess the fire spread hazard of EV’s and establish protection guidance. CSE shall be responsible for all parts of this study except for the experimental components which are the responsibility of the Testing Contractor. CSE shall be referred to as the Engineering Contractor herein.
- **Testing Contractor** – Organizations responding to this RFP to execute the testing portion of this research program shall be referred to as the “Testing Contractor” herein.

**Project Tasks:** For the overall project tasks, please refer to the full project scope document. The following project tasks which are described and clearly identified is what is expected from the Testing Contractor, who will be responding to the RFP.

Task 1: FPRF Engineering Contractor shall determine representative parking arrangements. See project scope document for more information.

Task 2: FPRF Engineering Contractor shall establish a research plan for full-scale vehicle fire tests. – The Testing Contractor shall coordinate with the FPRF Engineering contractor on the following sub-tasks.

**Note that the vehicles needed for testing will be provided by FPRF. Testing contractor shall take title to the electric vehicles and be responsible for disposal after the testing.**

- A) Engineering Contractor shall determine representative test configurations. Since test configurations have a significant impact on fire behavior, conduct a review of the most common parking arrangements (distance between vehicles, clearance to ceiling, etc.) to establish representative test configurations to be implemented within this experimental program. **(Testing Contractor to consult on this task)**
- B) Engineering Contractor shall define representative test variables. Using the findings from the Phase I report and other literature, define the key variables to be tested to determine the hazard classification of electric vehicles (e.g., what variables have the greatest impact). **(Testing Contractor to consult on this task)**
- C) Engineering Contractor shall establish appropriate, repeatable, and consistent ignition scenarios and test set-up that will produce consistent and comparable results. In consultation with the Engineering Contractor, the Testing Contractor shall design and construct mockup vehicles to be used in the testing as instrumented targets, in addition to the physical vehicles. The type of materials and construction required shall be specified. **(Testing Contractor to consult on this task)**
- D) Engineering contractor shall establish evaluation criteria against which the fire hazard and fire spread characteristics of electric vehicles can be assessed. **(Testing Contractor shall consult on this task)**

Task 3: Testing Contractor shall develop a formal experimental test plan. Using the information gathered in the above sub-tasks, develop an experimental test plan to be implemented in the subsequent tasks. The tests should focus on horizontal fire spread between vehicles (e.g., such as in traditional open garage scenarios). The formal experimental plan shall be reviewed with the project technical panel, prior to implementation.

- A) This test program should include multi-vehicle, full scale tests with consistent configurations (e.g., distance between vehicles, vehicle orientation, obstructions/barriers, opening to the exterior, ceiling height and presence of beam pockets). A series of proposed tests (calorimeter tests, full-scale fire tests in a garage setting, and sprinklered tests in a garage setting) are provided below. Appendix A also provides a list of anticipated requirements/materials/resources to carry out the testing.
  - i. **Testing Contractor** shall design and construct a mockup open and closed garage, for the purposes of testing. The Testing contractor shall also design and construct mockup vehicles (which will serve as an instrumentation framework) to capture measurements regarding fire exposure to adjacent vehicles. The design of the mockup garages and vehicles shall be reviewed with the project technical panel.
- B) The sprinklered tests should focus on the impact of sprinkler protection on fire spread. The sprinklered test program should include multi-car, full scale tests with representative

sprinkler protection and consistent vehicle configurations (e.g., distance between vehicles, vehicle orientation, obstructions/barriers, opening to the exterior, ceiling height and presence of beam pockets).

- C) The Test Contractor shall propose recommendations for how to improve efficiency of the proposed series of experimental tests and resources used.

Table 1: Proposed Series of Fire Tests

Test	Type	Variable	Details
1	Calorimeter	EV	<ul style="list-style-type: none"> <li>Establish baseline data</li> <li>Anticipated Measurements: HRR, temperature, heat flux, and any other relevant measurements.</li> </ul>
2	Open Garage	Spacing A*	<ul style="list-style-type: none"> <li>At least 2 vehicles (look at horizontal fire spread from one vehicle to the adjacent vehicle) in a garage setting.</li> <li>Variables: Spacing, beam height, and % opening (consistent with NFPA 88A opening %).</li> <li>Introduce airflow to simulate open garage conditions.</li> <li>Place a mockup vehicle/instrumentation on both sides to collect additional data.</li> <li>Have a charging station as a target to evaluate ignitability and contribution (if any) to the hazard.</li> </ul>
3	Closed Garage	Spacing A*	<ul style="list-style-type: none"> <li>2 vehicles (look at horizontal fire spread from one vehicle to the adjacent vehicle) in a garage setting.</li> <li>Variables: spacing, orientation, beam height               <ul style="list-style-type: none"> <li>Modify spacing; keep other variables consistent.</li> </ul> </li> <li>Place a mockup vehicle/instrumentation on either side to collect additional data.</li> </ul>
<b>Panel to review results of Tests 1, 2, and 3 to determine the parameters of Test 4</b>			
4	Garage (open/closed based on worst case result of tests 2 & 3).	Spacing B*	<ul style="list-style-type: none"> <li>2 vehicles (look at horizontal spread from one vehicle to the adjacent vehicle) in a garage setting.</li> <li>Variables: spacing, orientation, beam height, and % opening               <ul style="list-style-type: none"> <li>Modify spacing; keep other variables consistent.</li> <li>Open/closed based on worst case result of tests 2 &amp; 3.</li> </ul> </li> <li>Place a mockup vehicle on either side to collect additional data.</li> </ul>
<b>Before continuing to Test 5, confirm the sprinkler design with the panel.</b>			
5	Sprinkler in closed garage	Closed Garage + Sprinkler Design Density A	<ul style="list-style-type: none"> <li>Ignite one vehicle – with mockups on either side.</li> <li>Measure sprinkler activation time.</li> <li>Design density shall be based on current design requirements for closed garages.</li> <li>Worst case sprinkler location</li> </ul>
<b>Panel to provide feedback on sprinkler design of Test 6 based on the results of Test 5</b>			
6	Sprinkler in open garage	Open Garage + Sprinkler Design	<ul style="list-style-type: none"> <li>Ignite one vehicle – with mockups on either side.</li> <li>Measure sprinkler activation time.</li> <li>Worst case sprinkler location</li> </ul>

		Density TBD	
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\* Spacings A and B will be determined based on the findings of Task 1 and input from the technical panel.

**Task 4: Testing Contractor shall Implement the Experimental Test Plan for Full-scale Vehicle Fire Tests and the Engineering Contractor shall Analyze Test Results.**

- A) **Testing Contractor shall conduct Full-scale Fire Testing of Electric Vehicles.** Based on the experimental test plan established in Task 3, implement full-scale fire tests of the procured electric vehicles.
- B) **The Engineering Contractor Shall Analyze the Fire Test Data Collected in Task 4A.** The **Testing Contractor shall provide the test data** from Task 4A to the Engineering Contractor for Analysis, and provide consultation to clarify the data, as required.
- C) **The Engineering Contractor shall determine the occupancy/hazard classification and sprinkler protection criteria.** **The testing contractor shall consult with the engineering contractor** on this task, to obtain the information on the sprinkler protection criteria to be used in the sprinklered tests in Task 5A.
- D) **Testing Contractor shall Implement Sprinklered Fire Test of Modern Vehicles.** Based on the experimental test plan established in Task 3 and the sprinkler protection criteria identified in Task 5A, implement sprinklered fire tests of electric vehicles that are representative of the wide range of parking structures and vehicles in the market.
- E) **Engineering Contractor shall analyze the Sprinklered Test Data.** **Testing Contractor** shall provide the test data from Task 5B to the Engineering Contractor, and provide consultation to understand the data, as required.
- F) **Testing contractor shall develop an experimental test report.** This shall include a summary of the tests and results and will be reviewed with the panel.

**Final Report:** The Testing Contractor shall coordinate with the FPRF Engineering contractor on the final report.

**Implementation:** This research program is led by the Fire Protection Research Foundation and will be conducted in accordance with the "[Research Foundation Policies for the Conduct of Research Projects](#)". The project will be guided by a Project Technical Panel who will provide input to the project, recommend contractor selection, review periodic reports of progress and research results, and review the final project report. At a minimum, five Panel meetings will be held: project kick-off, review of experimental test plan, review of full-scale burn test results, review of sprinklered test results, and review of the draft final report. The Foundation will provide documentation of all Panel meetings.

**Deliverables:** The testing contractor shall:

- Deliver an experimental test plan, which shall be reviewed with the panel.
- Provide interim updates to the panel during the testing as needed.
- Make the data, photos, and videos captured during this project available to the Foundation.
- Deliver an experimental test report that includes a summary of the tests and results.
- Consult with the Engineering Contractor on the results of the testing presented in the final report.
- Participate in at least one dissemination activity (e.g. presentations at technical conferences/technical committees, webinars, or published article opportunity).

**Intellectual Property:** The Research Foundation will retain rights to all project deliverables including, the project report, which will be published on the Foundation website. The project deliverables also include the test data, videos and images captured and data collected over the course of the project.

**Schedule and Costs:** Proposals for this project shall include an estimated total cost, broken down by task and test. The proposed schedule is provided in the table below. Suggested modifications to the proposed schedule can be provided with substantiation.

Tasks	Deliverable Timeline	Estimated Dates
Proposals due		2 July 2021
Selection of Contractor		16 July 2021
Task 3: Development of Experimental Test Plan	12 weeks from project initiation	October 2021
Task 4: Execute of Experimental Test Plan	28 weeks from project initiation	February 2022
Task 4(e): Development of Experimental Test Report	32 weeks from project initiation	March 2022

**How to Respond:** Letter proposals shall be submitted electronically to Victoria Hutchison, Research Project Manager of the Foundation, at [vhutchison@nfpa.org](mailto:vhutchison@nfpa.org) no later than **5:00 pm Eastern time 2 July 2021**. For additional details see the “[Research Foundation Policies for the Conduct of Research Projects](#)”, the [Foundation Operating Principles](#), and “[Research Project Guidelines for Contractors](#)” on the Foundation website at: <https://www.nfpa.org/foundation>.

Each proposal shall include a description of the following weighted evaluation criteria: problem understanding (25%), technical merit (include scope and approach) (25%), prior relevant experience and personnel expertise (25%), and budget broken down by task and by test (15%). An additional criterion, current level of active foundation engagement, will be considered as the remaining 10% weighted evaluation criteria.

Please note, the body of the research proposal submittals shall not exceed six pages in length, including a short bio of the proposed personnel and not including the cover page. Any additional relevant information (e.g., Project participants’ CVs or resumes, letters of support, detailed description of past relevant experience, detailed description of RFP-Respondent’s organizational facilities, competencies, other capabilities, and references) not covered in the body of the proposal should be appended to the proposal, with a maximum combined page limit of 12 pages, including the body of the proposal and appendices.

Additionally, all bidders must submit a completed [disclosure statement](#) with the proposal (this does not count towards the page limit). This form can be downloaded [here](#).

**Note:** This project will proceed only on the basis of receipt of a proposal deemed acceptable to the Foundation and the project sponsor(s) and if the funding threshold is reached. Information on the Foundation’s policies for the conduct of research can be found on our [website](#). Services received are subject to our [standard contractual terms](#).

**Appendix A – Material Resources**

Below is a list of material and lab resources that are anticipated to be required for this project.

*Table 2: Anticipated requirements for material and lab resources*

<b>Material/Resource</b>	<b>Specifications</b>	<b>Responsibility</b>
<b>Vehicles</b>		
8 vehicles	8 electric vehicles	Procurement – FPRF, Disposal – Testing Contractor
8 mockup vehicles	To be determined by the testing contractor and reviewed with the project technical panel. Mockup vehicle should serve as an instrumentation framework to capture measurements.	Testing Contractor
<b>Parking Structure Mock-up</b>		
Open and closed parking structure mockup	Mockup of single-story parking garage, covering up to five parking spaces. Total area of approximately 50’ x 25’ is recommended. This mockup should be used for the implementation of the testing. Ideally the mockups should be able to be used for all tests. For open garage mockup, the opening shall be aligned with the requirements of NFPA 88A.	Testing Contractor
Electric Charging Station	Testing contractor shall provide at least one electric vehicle charging station to include in the test series.	Testing Contractor
<b>Testing Requirements</b>		
Lab Space/Testing Facility/ Calorimeter Capacity	<p>Lab capabilities shall be provided in the proposal (appendix is acceptable). Testing contractor shall demonstrate their ability to handle the anticipated scale of the proposed tests.</p> <ul style="list-style-type: none"> <li>• Ability to accurately measure HRR from one fully involved vehicle.</li> <li>• 15 MW capacity calorimeter or greater recommended.</li> <li>• Only one test is expected to be run in a calorimeter.</li> <li>• Ability to maintain consistency and repeatability of testing over an extended period of time.</li> <li>• Ability to move and maneuver vehicles in tight-spaces.</li> </ul>	Testing Contractor
Testing Instrumentation	<p>Including, but not limited to,</p> <ul style="list-style-type: none"> <li>• Thermocouples</li> <li>• Heat Flux Gauges</li> <li>• Mass-loss rate</li> <li>• CO, CO<sub>2</sub>, O<sub>2</sub> concentrations</li> <li>• Sprinkler activation time</li> <li>• Others as applicable</li> </ul>	Testing Contractor