

## **PROGRAM FOR THE STUDY OF FIRE PATTERNS**

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### **ABSTRACT**

Fire and arson investigators often rely on fire patterns to determine the origin of fires. Fire patterns are visible manifestations of the heat and smoke produced by the fire which remain on room interior surfaces and furnishings after the fire is extinguished. This program which was sponsored by the US Fire Administration, included a series of ten full-scale compartment (room) fire tests that were designed to evaluate the fire characteristics of room fires under actual fire conditions and the effect those conditions had on fire pattern formation. Particular inquiry and analysis was made into the unique and distinguishing characteristics of fire patterns on ceilings, walls, and floors caused by accelerated (i.e. arson) verses non-accelerated fires.

There is no known or current fire research to evaluate the fire patterns which fire investigators and analysts are commonly using to assess fire origins and fuels. This program set forward a protocol for a series of initial tests which will set a standard of background research which the professional fire investigation community can use to asses the propriety of their fire pattern opinions.

The production of this program for the study of fire patterns involves the specification of the test room, ignition source, test fire(s), instrumentation, test procedures, safety, observations and data gathering, analysis and reporting of results.

The full-scale laboratory testing utilized two baseline runs where the test room was not furnished. Eight pattern analysis tests followed where the test room was furnished. A total of four tests were conducted in the NIST-BFRL full scale fire test facility. The remaining six tests were done in residential structures in Alabama and California.

### **TEST PLAN**

The pattern tests were conducted in test rooms which were instrumented to provide temperature, heat release rate, oxygen concentration, and radiant energy data. The test plan was put together to satisfy both the needs of scientific data collection data and the production of usable and representative fire patterns. The goals of the testing included being able to relate compartment fire dynamics with the production, appearance, and persistence of fire patterns.

The design, construction, and furnishing of the NIST-BFRL test room was done to give reproducible results and to closely represent typical residential rooms. This room was 12 ft by 12 ft, with an 8 ft high ceiling. It had a standard size door opening and a 3 ft by 3 ft glass window 42 in. above the floor. It was constructed in a manner to closely simulate common residential construction which included gypsum

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wallboard on wood structural members. The room was provided with bedroom type furnishings and a floor finish. Three types of floor finish were used: carpet on padding, vinyl tile, and wood. A total of four tests were done in this facility with this test room.

The rooms in the residential structures were selected based on their similarity to the NIST-BFRL test room. The same furnishings and floor finishes were used. It was not possible to record heat release rate data for these tests but data which was recorded included temperature, radiant heat flux, and oxygen concentration. A total of six tests were done in these structures.

Photographic records of the tests included video cameras at view ports in the door, in the wall with the window, and in the opposite wall where the fires will originate. Still photography was utilized to record fire conditions in the room, and to fully document the patterns which were created on all surfaces of the room and on the furnishings. Chemical analysis was conducted by the Bureau of Alcohol, Tobacco and Firearms (BATF) National Laboratory of accelerant evidence which was collected.

Ignition sources were either pieces of newspaper or a gasoline. In five of the tests the gasoline was poured on the floor from the interior of the room towards the door. In the other five tests the fire was started by placing several sheets of newspaper in a stuffed chair and igniting the newspaper.

The tests were allowed to burn long enough that flashover conditions were produced. Flashover conditions were observed in eight of the ten tests.

## **RESULTS**

Generally, the testing indicated that the patterns which remain on room surfaces and furniture items were useful for determining the point of origin of these fires. Pattern characterizations which have been used in the past by fire investigators were seen in these tests. This includes the truncated cone, clean burn and calcination of gypsum wallboard. With regard to floor patterns, it was found that when flashover has occurred patterns are made on the surface of the floor as a result of thermal exposure and combustion. Floor patterns were also observed under furniture items as a result of the generation and combustion of an ignitable liquid from the materials of the furniture item, especially those containing polyurethane foam. In the cases where an ignitable liquid was used as an accelerant, the patterns from the liquid were difficult or impossible to discern. When flashover conditions were not produced with the use of an accelerant, the patterns were easy to discern. Another pattern which was discernible was when a piece of cloth soaked in gasoline was used as a trailer. It was found that low points of burning were present away from the point of origin, in the case of accelerated and non-accelerated fires.

Another significant result was regarding ventilation. Patterns were produced, altered or affected by the ventilation conditions in the rooms. The presence of a fresh air floor jet was indicated by the production of patterns on wall surfaces opposite door openings. It was also found that areas of hotter fire gases were produced under open windows, which was indicated by clean burn patterns on the walls under these windows.

## **CONCLUSIONS**

This research project will greatly assist the fire investigator in the interpretation of fire patterns used to establish the origin of fires. Some patterns used in the past were confirmed, some were found to be invalid, and new ones were discovered. Additional work is needed in this area to further increase the understanding of fire patterns and to look at different fire conditions and different room configurations, finishes, and furnishings.