Test Methods and Descriptions

Tests were conducted in three phases: 1998 laboratory tests, field tests conducted in the fall of 1998 and 1999, and laboratory tests conducted in the spring of 2000. While the primary focus of these tests was to determine the accuracy and to compare the results from several identical instruments, operational and reliability characteristics were also being evaluated.

Laboratory Tests During 1998

Objectives—The objectives of the 1998 laboratory tests were to determine whether the optical and gravimetric instruments showed significant differences when measuring smoke particles produced from burning biomass under controlled conditions. If possible, we hoped to determine a correction curve for the optical instruments. A report on these tests, *Laboratory Evaluation of Two Optical Instruments for Real-Time Particulate Monitoring of Smoke* (9925-2806-MTDC, figure 7), was published in 1999.

Location—The laboratory tests were conducted at the Fire Sciences Laboratory's large (131,000 ft^3) combustion chamber. The instruments were placed side by side and operated on a platform 55 ft above the chamber floor (figure 8).

Instruments—Two optical instruments were evaluated in the 1998 laboratory tests, the MIE DataRam and the Radiance Research nephelometer. The MIE DataRam was configured with a $PM_{2.5}$ cutoff device and inlet heater. The Radiance Research nephelometer measured total suspended particulate. Two different gravimetric devices were used, an FRM $PM_{2.5}$ sampler manufactured by Rupprecht and Patachnick and a $PM_{2.5}$ sampler developed by the Fire Sciences Laboratory for airborne smoke studies. The FRM was available only for a few tests. The Fire Sciences Laboratory's gravimetric sampler was used for all tests.

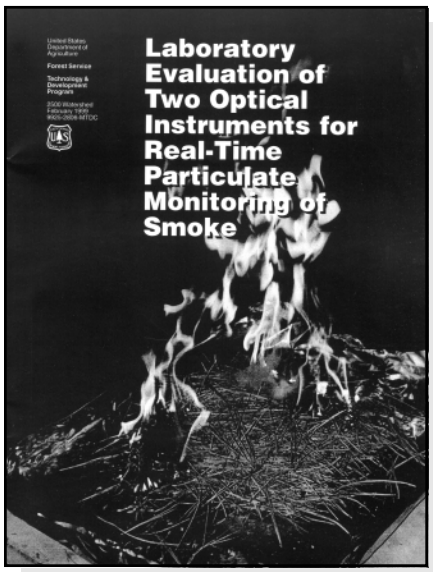

Figure 7—A report (9925-2806-MTDC) was published in 1999 detailing the laboratory evaluation of two real-time particulate moniotrs.

Test Descriptions—The experiments were conducted at ambient conditions inside the closed chamber at temperatures of 70 to 90 °F and 30- to 50-percent relative humidity. Small beds of flaming and smoldering ponderosa-pine needles on the chamber floor generated the smoke for most of the tests (figure 9). Several tests were conducted using smoke generated from burning duff. A total of 66 tests were conducted. The duration for each test varied depending on the estimated particulate concentration. Higher concentration tests were shortened to prevent clogging the filters. Lower concentration tests took longer to accumulate enough mass on the filters for accurate weighing. The average test took about an hour.

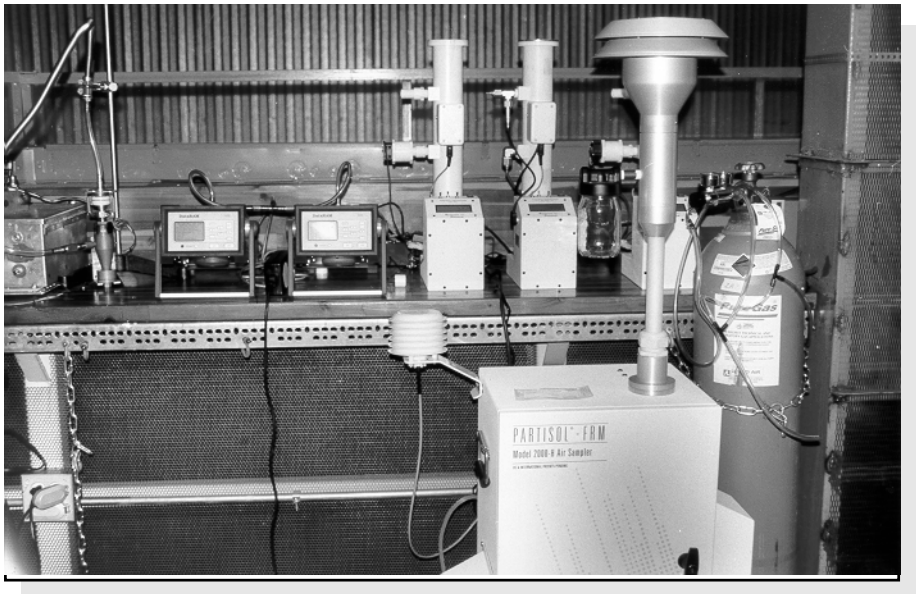

Figure 8—Instrument layout on the smoke-sampling platform in the combustion chamber.

Figure 9—An example of the fire beds of pine needles used to produce smoke in the laboratory combustion chamber.

Field Tests During 1998 and 1999

Objectives—The objectives of the field tests were to validate the 1998 laboratory results by comparing results from the optical instruments to those from a gravimetric instrument in a field environment. The instruments were placed side by side downwind of prescribed burns or wildland fires to gather data from the smoke (figure 10). The field tests also gave us the opportunity to obtain field experience with each of the instruments.

Location—The field tests were conducted near prescribed and wildland fires in and around the Missoula and Bitterroot Valleys in Montana and northern Idaho. The distance from the burn to the instruments varied, depending on the availability of secure land where the instruments could be set up. Because the instruments were set up in relatively pristine airsheds, elevated particulate levels were assumed to be from smoke.

Instruments—Only the DataRam and Radiance Research nephelometer were available for the field tests conducted in 1998. The Fire Sciences Laboratory's gravimetric instrument was used for gravimetric comparisons. The Met One GT-640 and the Andersen aethalometer were also available for the 1999 Field tests. The BGI PQ200 was used as the gravimetric standard for all the 1999 field tests.

Test Descriptions—The instruments were typically placed side by side and left overnight where it appeared residual smoke from the burns would settle. All instruments were equipped with their respective $PM_{2.5}$ cutoff inlets and inlet heaters. Temperature, relative humidities, and wind all varied from test to test. The instruments were powered by a Honda 1,000-W portable generator modified to operate for extended periods of time.

Laboratory Tests During 2000

Objectives—The 2000 laboratory tests had several objectives. One objective was to conduct tests similar to the 1998 laboratory tests on several new instruments to compare their performance to the other instruments. The new instruments included the Met One GT-640, the Optec NGN-3 nephelometer, and the Andersen aethalometer. Another objective was to obtain samples at lower concentrations of particulate (under 150 $\mu g/m^3$) than were measured during

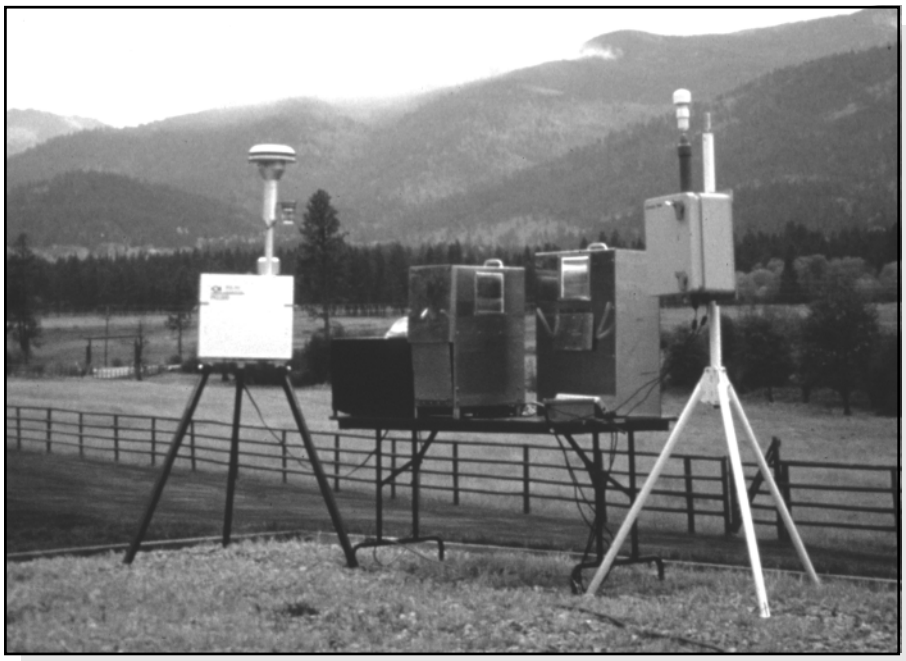

Figure 10—Instrument layout during the 1999 field tests.

the previous laboratory tests. We also conducted several tests at high relative humidities (above 70 percent) to determine the effectiveness of the inlet heaters. Finally, we compared gravimetric samplers.

Location—The 2000 laboratory tests were conducted at the Fire Sciences Laboratory's smoke chamber. The instruments were placed side by side on a platform 55 ft above the chamber floor.

Instruments—The instruments included in the 2000 laboratory tests were:

- Two MIE DataRam instruments.
- Two Radiance Research nephelometers.
- Two Met One GT-640's.
- One Optec NGN-3 nephelometer.
- An Andersen aethalometer.
- Two BGI PQ200's.
- A Fire Sciences Laboratory $PM_{2.5}$ gravimetric sampler.

A total of 11 instruments and seven different makes or models were tested. All instruments were configured with their respective $PM_{2.5}$ cutoff inlet and inlet heater. To maintain consistency with the previous laboratory and field tests, the Radiance Research nephelometer was configured to estimate total suspended particulate.

Test Descriptions—Except for the high-humidity tests, all the experiments were conducted at ambient conditions inside the closed chamber. Again, very small beds of dry ponderosa-pine needles (weighing from 50 to 150 g) were burned to generate the smoke. These beds were much smaller than in the 1998 tests where we burned more needles to generate higher particulate levels.

A number of tests were conducted to evaluate the performance of identical instruments, specifically the MIE DataRam, the Radiance Research nephelometers, the Met One GT-640's, and the FRM samplers. We not only determined the accuracy of each real-time instrument compared to the gravimetric instrument, but we also compared each of the instruments to another like it.

High-humidity tests were performed between similar instruments with and without their respective inlet heaters.