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Book of Abstracts
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Kellie Ann Beall, Editor

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Gaithersburg, Maryland 20899

United States Department of Commerce
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Drop Size Measurements in a Fire Sprinkler Using an Agricultural Testing Method

Linda G. Blevins, Building and Fire Research Laboratory
National Institute of Standards and Technology

Joe C. Oliphant, Center for Irrigation Technology
California State University, Fresno

The NIST Industrial Fire Simulation (IFS) computer model is being adapted to predict the interaction between sprinklers and fires at realistic scales [1]. The new formulation relies on a sprinkler submodel calibrated with experimentally measured water drop size distributions. Measuring drop sizes for large scale fire sprinklers is challenging because the range of diameters is large (~10 μm to ~5 mm) and instruments must be protected from flowing water (~200 L/min). Agricultural researchers experience similar challenges in studying crop-irrigation sprinklers. They are interested in measuring drop size to optimize the uniformity of a sprinkler's ground application rate, and have methods in place to perform the measurements [2]. Because many agricultural sprays are similar in drop size and flow rate to those from large fire sprinklers, NIST is exploring the possibility of applying agricultural measurement methods to fire sprinklers in support of the IFS effort. Initial findings of the investigation are reported here.

Measurements of drop size distribution in a fire sprinkler were made in a large agricultural sprinkler testing facility. An optical array probe consisting of a ribbon of laser light illuminating a photodiode detector array was used [3]. In this instrument, droplets pass between the laser and detectors, and a maximum horizontal drop width (diameter) is determined for each in-focus droplet from its shadowing pattern on the photodiodes. Corrections are made for drop overlap and partial drop shadowing [4]. The range of detectable drop widths is 0.2 mm (0.008 in) to 12.4 mm (0.49 in), and the probe is ruggedly designed with splash guards to withstand large flows. It should be noted that an optical array probe has also been used for fire sprinkler research, although for a smaller range of detectable drop sizes [5]. Rain-gauge style water collectors were used to determine water application rates [6]. The collectors are 10-cm in diameter and are placed at discrete intervals, providing less area coverage than that obtained by contiguously placed 30 cm x 30 cm x 30 cm collection pans used for fire sprinkler distribution tests [7]. The sprinkler tested was a 13.5-mm (17/32 in) diameter orifice, upright model with 130 kPa (19 psig) delivery pressure. Drop size spectra and application rates were measured at ground level with the sprinkler mounted at the end of a 4.5-m (14.8 ft) high, cantilevered pipe. Measurements were made at six equally spaced radii between 0.5 m (1.6 ft) and 3.0 m (9.8 ft) along a direction perpendicular to the sprinkler brace.

Median drop diameters based on volume and number, shown in Fig. 1, are defined in the following way: Half of the sprinkler's *total water flow* at each location exists as drops which are larger (or smaller) than the volume-based median, and half of the *number of droplets* at each location are larger (or smaller) than the number-based median. Volumetric median drop sizes are 2.2 mm at a radius of 0.5 m, and increase to 3.3 mm at a radius of 3.0 m. Number-based median drop sizes range from 0.5 mm to 1.0 mm. The increase in median drop size with radius is consistent with

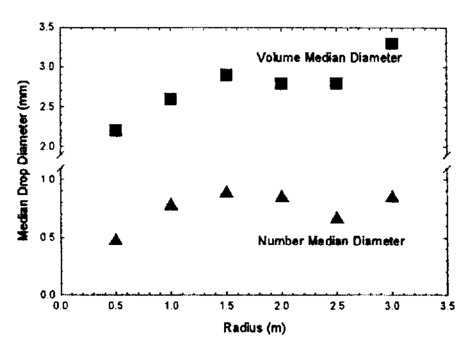

Fig. 1 Radial profiles of volume-based and number-based median drop diameter

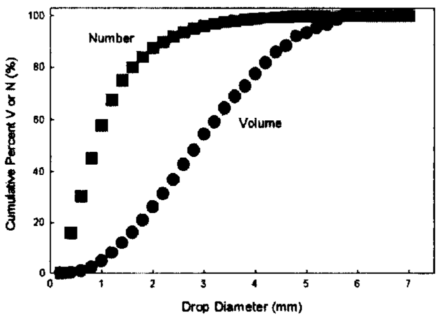

Fig. 2. Local volumetric and number-based size distributions for 1.5-m radial location.

other fire sprinkler results described in Ref. 5. Examples of local drop size distributions for the radial location of 1.5 m are shown in Fig. 2. A number distribution is shown because the IFS sprinkler submodel is based on the random selection of sizes from number-based distributions. These drop size data are presently being analyzed at NIST to determine their reliability.

Figure 3 depicts the application rate profile. The application rate is maximum at 43 cm/hr (0.18 gpm/ft^2) at a radius of 1.5 m. For agricultural testing, the application rate is used to combine local drop size distributions into an overall volumetric distribution for the sprinkler. This involves assuming that the application rate and drop sizes measured at a given radial location are constant throughout an annular ring bisected by the radius, computing individual volumetric flow rates for each ring, and then computing the overall distribution as a volume-weighted sum of the individual size distributions. This procedure was found to be inadequate for the present sprinkler because the individual annular volumetric flow rates sum to 114 L/min (30 gpm), which is just 55 % of the total water flow rate through the sprinkler. Hence, 45 % of the sprinkler flow is not accounted for when the constant-annular-ring assumption is made. This could be because the measurements were not spaced closely enough or because the distribution pattern is less uniform than that of a typical agricultural sprinkler. A procedure involving closely-spaced measurements over the entire two dimensional sprinkler distribution is more appropriate for fire sprinklers [e.g., as in Ref. 5].

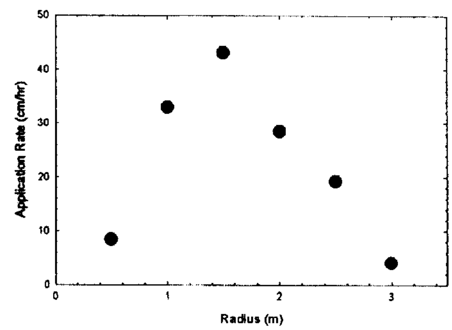

Fig. 3. Radial profile of application rate.

In summary, an agricultural sprinkler drop size measurement method was applied to a fire sprinkler. Local drop size data are presently being analyzed at NIST. The agricultural procedure must be modified to obtain useful overall size distributions for fire sprinklers with non-uniform distribution patterns.

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