An experimental investigation of spray formation as affected by sprinkler geometry

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The PIV/Shadow Imaging System was used to gain understanding of sprinkler spray formation and its relationship to sprinkler geometry. A fire sprinkler typically consists of the following four key components: deflector tines, deflector slots, boss above the deflector, and sprinkler frame arms. Prototypes representing these four key sprinkler components were fabricated to evaluate their effects on the spray formation process. These prototypes were designated as: disk-sprinkler, slot-sprinkler, boss-sprinkler and arm-sprinkler, by which the effects of deflector diameter, deflector slot width, boss configuration and sprinkler frame arm, could be evaluated separately. The water sheet thickness formed on the deflector, slot spray discharge angle, sheet breakup distance, water flux, drop size and drop velocity were measured. It was found that deflector diameter and boss structure have little impact on drop size and sheet breakup distance. However, wider slots form larger drops. At an operating pressure, the slot spray discharge angle is insensitive to the slot width, but the boss helps directing the spray toward the sprinkler centerline. The frame arm tends to produce a vertical spray sheet downstream the frame arm, which increases the complexity of overall spray formation. The spray atomization model requires the information of water sheet thickness and velocity at the deflector edge. An integral model was developed to calculate the development of water sheet thickness and velocity on the deflector for different degrees of viscous effect exerted by the deflector. An empirical correlation was also established to estimate the spray flux fraction discharged from a deflector slot, which is another information required by the spray atomization model.