Volumetric velocity measurements of vortex rings from inclined exits

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Abstract Vortex rings were generated by driving pistons within circular cylinders of inner diameter $D = 72.8$ mm at a constant velocity U_0 over a distance $L = D$. The Reynolds number, $U_0 L/(2\nu)$, was 2500. The flow downstream of circular and inclined exits was examined using volumetric 3-component velocimetry (V3V). The circular exit yields a standard primary vortex ring that propagates downstream at a constant velocity and a lingering trailing ring of opposite sign associated with the stopping of the piston. By contrast, the inclined nozzle yields a much more complicated structure. The data suggest that a tilted primary vortex ring interacts with two trailing rings; one associated with the stopping of the piston, and the other associated with the asymmetry of the cylinder exit. The two trailing ring structures, which initially have circulation of opposite sign, intertwine and are distorted and drawn through the center of the primary ring. This behavior was observed for two inclination angles. Increased inclination was associated with stronger interactions between the primary and trailing vortices as well as earlier breakdown.

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