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Vortex-breakdown and wall-separation states in swirling flows in a straight pipe YUXIN ZHANG, ZVI RUSAK, Rensselaer Polytechnic Institute, SHIXIAO WANG, The University of Auckland, New Zealand — The appearance of vortex-breakdown and wall-separation states in various incoming swirling flows to a straight circular pipe is investigated. Fixed-in-time profiles of the axial and circumferential velocities and of the azimuthal vorticity are prescribed at the pipe inlet. A parallel flow state is set at the pipe outlet. Following the theory of Wang & Rusak (1997), the outlet state of the steady flow problem is determined for a long pipe by solutions of the columnar (axially-independent) Squire-Long equation. For each of the incoming flows studied, these solutions include the base columnar flow state, a decelerated flow along the centerline, an accelerated flow along the centerline, a vortex-breakdown state and a wall-separation state. These theoretical predictions are numerically realized by flow simulations based on the unsteady flow equations. The simulations shed light on the base flow stability and the dynamics of initial perturbations to the various states. The present study extends all the six bifurcation diagrams of solutions studied in Leclaire & Sipp (2010), who stopped the development of branches of steady states once breakdown and wall-separation states first appear.

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