Lean blowout is experimentally investigated for premixed bluff-body flames under various inlet velocity conditions, pressure gradients, and turbulence conditions to study the influence of fluid mechanics on the lean blowout process. A premixed combustion facility paired with a bluff-body flame stabilizer is used for the study. For all experiments, lean blowout is induced by temporally decreasing the fuel flow rate into the reactant stream. A suite of high-speed optical diagnostics are simultaneously employed to capture the transient blowout process, including: Particle Image Velocimetry (PIV), stereoscopic PIV, and C2*/CH* chemiluminescence imaging. These diagnostics allow for the instantaneous flame boundary, velocity fields, equivalence ratios, and local flame strain rates to be evaluated during blowout. For all testing conditions, the results show that the blowout process is highly coupled to the fluid mechanics within the reacting domain and blowout is driven from flame-flow interactions (i.e. flame-vorticity interactions or flame-turbulence interactions). The results also demonstrate that altering the vorticity dynamics or turbulence conditions within the reacting domain can profoundly augment or attenuate the blowout process.