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The rough-wall turbulent boundary layer from the hydraulically smooth to the fully rough regime[1] MICHAEL SCHULTZ, KAREN FLACK, United States Naval Academy — Turbulence measurements for rough-wall boundary layers are presented and compared to those for a smooth wall. The rough-wall experiments were made on a three-dimensional, rough surface geometrically similar to the honed pipe roughness used in the study of Shockling, Allen, & Smits (2006). The present work is unique in that it covers a wide Reynolds number range (Re_θ = 2,180 – 27,100), spanning the hydraulically smooth to the fully rough flow regimes for a single surface, while maintaining a roughness height that is a very small fraction of the boundary layer thickness. In this investigation, the root-mean-square roughness height was at least three orders of magnitude smaller than the boundary layer thickness, and the Kármán number (δ^+), typifying the ratio of the largest to smallest turbulent scales in the flow, was as high as 10,100. The mean velocity profiles for the rough and smooth walls show remarkable similarity in the outer layer using velocity-defect scaling. The Reynolds stresses and higher order turbulence statistics also show excellent agreement in the outer layer. The results lend strong support to the concept of outer layer similarity for rough walls in which there is a large separation between the roughness length scale and the largest turbulence scales in the flow.

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