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The multiple side-branch system as a model for a corrugated pipe

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Corrugated pipes are used as flexible risers in offshore natural gas production and for vacuum cleaners. Such pipes can display whistling. As theoretical models are available to predict the aero-acoustical behaviour of closed side branches [1], we consider a row of equally spaced closed side branches along a pipe, as a model for a corrugated pipe. We consider side branches with a diameter D and depth L equal to the main pipe diameter, placed at a distance of three diameters from each other. For systems of 11 or 12 side branches the lowest resonance modes are reasonably well predicted by assuming $n(\lambda/2)$ standing wave modes with an effective speed of sound c_{eff}[2]. Whistling is observed for the n=2 and n=3 modes with a pressure fluctuation amplitude $p'/(\rho_0 c_0 U_0)=O(2\times10^{-2})$ similar to that observed for sharp edges corrugations in a corrugated pipe (with ρ_0 the fluid density, c_0 the speed of sound and U_0 the main flow velocity). The Strouhal number of these oscillations is $Sr_D=(f\cdot D)/U_0\simeq0{,}70$. This is higher than typical values observed for corrugated tubes [3].

References:
[1] J.C.Bruggeman et al., J. Sound and Vibration 1991 150(4) 371-393. [2] J.W.Elliot, in "Lecture Notes on the Mathematics of Acoustics" M.C.M.Wrigth, Imperial College Press, London (2005). [3] S.Belfroid et al., ASME paper PVP2007-26503.