

# Silo outflow of soft frictionless spheres

*CJ OGF"OQJCOGF"CNK"CUJQWT"CJ OGF".Vqtuvgp"Vtkvvggn."Vc o cu"D<sup>3</sup>/t/w<sup>3</sup>p{k."*  
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## Abstract

Outflow of granular materials from silos is a remarkably complex physical phenomenon that has been extensively studied with simple objects like monodisperse hard disks in two dimensions (2D) and hard spheres in 2D and 3D. For those materials, empirical equations were found that describe the discharge characteristics. Softness adds qualitatively new features to the dynamics and to the character of the flow. We report a study of the outflow of soft, practically frictionless hydrogel spheres from a quasi-2D bin. Prominent features are intermittent clogs, peculiar flow fields in the container and a pronounced dependence of the flow rate and clogging statistics on the container fill height. The latter is a consequence of the ineffectiveness of Janssen's law: the pressure at the bottom of a bin containing hydrogel spheres grows linearly with the fill height.

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