

## **Ask Joe! Column**

### **Flow in Bulk Storage Bins**

Guest article by Lyn Bates of Ajax Equipment, Ltd.

It is useful to set out some terms and definitions for flow patterns in bins. These help to clarify features of the different zones of flow and overall patterns of behavior. There are slight international differences in some descriptions, so the list includes most common terms. More importantly, it sets out the distinguishing features of the differing types and attempts to remove any confusion between regions of flow with similar behavior, and overall flow patterns, which are usually of a composite nature.

Note that a distinction must be made between global flow regimes, as in silos and bulk storage containers where flow behavior may be complex or compound, and zones of flow behavior, where the nature of the flow pattern is similar over the whole zone.

#### **Coherent Flow and Plug Flow**

The en-mass movement of a particulate array, without dislocation of the points of co-ordination of the constituent particles. In rheological terms this mode is not 'flow' as no deformation of the structure takes place.

#### **Bed Flow**

Movement of a bulk mass within a parallel confined channel, with slip taking place on all wall contact surfaces while flow velocity variations occur across the flow channel. Note that a parallel flow channel is often comprised of a regime that changes from coherent movement to bed flow because the lower part of the section has velocity contours imposed by the following section of the flow channel. The transition from plug (or coherent) flow, to bed flow is virtually imperceptible.

#### **Mass Flow**

Movement of a bulk mass in a converging flow channel, with slip taking place on all wall contact surfaces.

#### **Internal Flow and Core Flow**

A flow channel confined within a static mass of like product.

#### **Poured Repose**

An unconfined surface layer of flow, in which fresh product runs by gravity over an inclined bed of previously deposited material. This normally occurs in the filling of a bulk storage container from a single point of supply.

#### **Drained Repose**

An unconfined surface layer of flow, in which previously deposited material disengages from the settled mass, to flow by gravity over the remaining inclined bed of product.

#### **Avalanching**

Intermittent motions of 'poured' or 'drained' repose in which surges of unconfined flow occur due to transient instabilities of flow restraining surface irregularities.

## **Terracing**

A phenomenon of collapsing sections of stored material into a 'draining' flow channel. It is characterized by the formation of a growing 'cliff' at the boundary of an unstable 'rathole' until an inclined plane of failure develops under the surface of the material to cause the coherent slip of a body of product towards the draw-down region. A well developed system of this form is comprised of irregular concentric 'steps' from the unchanged surrounding surface to the central region of draw. Generally, the central region breaks up by convergence into chaotic chunks of disturbed masses of weak cohesion.

In plan, the velocity discontinuities tend to follow spatial orientation as the converging pattern closes in a similar manner to a camera iris rather than fail in compression due to the dominance of circumferential stress. This behavior reflects the cohesive strength of a settled product developing local failure planes as stresses accumulate to exceed a threshold unconfined strength value.

## **Flushing and Flooding**

The fluid-like behavior of a dilated bulk product flowing without restraint due to virtual absence of internal shear strength: usually, a consequence of the presence of excess gas in the interstitial voids sustaining the mass in a hydrodynamic manner to prevent the development of particle to particle frictional forces.

## **Cohesive Arching**

The formation of a stable flow obstruction over an outlet or within a flow channel due to the bulk strength of the material exceeding the unconfined failure strength at which the span of the arch would collapse because of the stresses acting on the mass.

### Mechanical Arching and Structural Arching

The formation of a stable flow obstruction resulting from the particulate constituents coming together to form a load bearing arch that is capable of sustaining the superimposed forces acting from the flow channel.

## **Dynamic Arching**

The formation of unstable flow obstructions caused by either transient cohesive arches within the flow channel, or erratic flow fluctuations resulting from intermittent and unstable particulate structures that form in the flow channel. The phenomena are characterized by regions of dilated bulk material under the moving arched region, as flow is restrained by the temporary impediment to smooth deformation of the mass.

## **Piping and Ratholes**

A stable void that develops through a mass of static bulk material as the live internal flow channel runs clear of product. The unconfined walls of the 'pipe' or 'rathole' having a bulk strength exceeding the 'unconfined failure strength',  $F_c$ , of the mass. Note a large diameter of 'pipe' or 'rathole' is less stable than a smaller one, hence a 'critical rathole size' is that diameter at which a stable rathole cannot form within the bulk material.

## **Radial Flow**

A flow channel that converges symmetrically in the horizontal plane.

## **Plane Flow**

A flow channel that converges in one horizontal plane only.

## **Asymmetric Flow**

A converging flow channel with different rates of convergence in differing axes of the horizontal plane.

## **Sigma Two Relief**

A specific form of asymmetric flow in which the flow channel simultaneously converges in one horizontal plane and diverges in the other, usually at a lower rate. The effect of minor divergence is to relax the minimum principal stress confinement and allow easier deformation. Flow is then possible through narrower openings and wall slip at lower converging angles.

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**Welcome to Ask Joe!**, a monthly column by our resident materials handling guru, Joe Marinelli of Solids Handling Technologies. Joe addresses the issues that bug you the most. And Joe knows!! Formerly with Jenike & Johanson, Solids Flow and Peabody TecTank, Joe is an expert on materials handling.

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Guest articles for the **Ask Joe!** Column are always welcome, for more information please contact Joe Marinelli directly at his email address: [joe@solidshandlingtech.com](mailto:joe@solidshandlingtech.com).

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