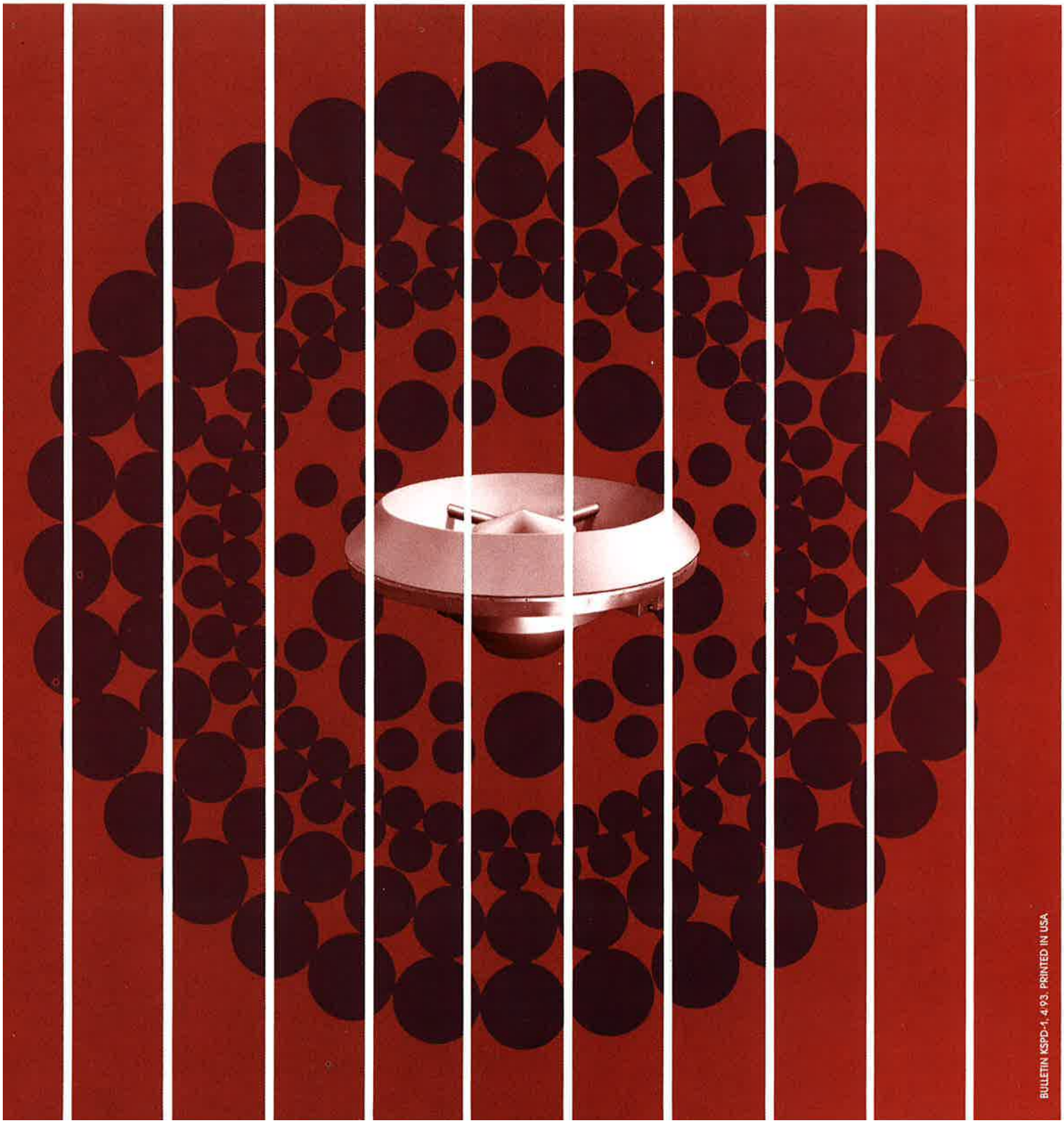
Induced
Vertical Flow

Storage Pile Dischargers Achieve "Expanded Flow"

Kinergy
Corporation



BULLETIN KSPD-1, 4.93. PRINTED IN USA.

Conceptual Comparison

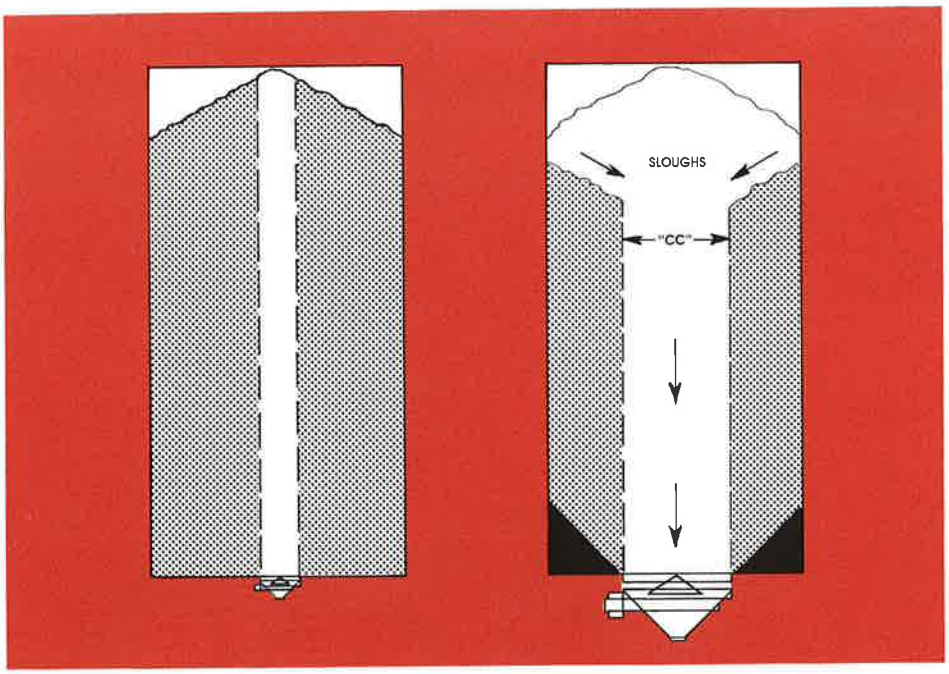


Fig. 1: When discharging flat bottom bins, only a core or rat-hole will be discharged when the **critical core (cc)** is not exceeded (left). The sloughs from the side wall will innately fall in only when the inlet of the Bin Activator is large enough (right).

Conceptual Comparison

Storage piles are an economical and convenient means for storing large quantities of bulk solids. To recover their contents, there are three basic methods to consider. Each complements the other. When one or even two are not appropriate for a given application, the other usually is.

"Impelled Retrieving" conveys, digs, scrapes, or scoops the material to remove it from the pile. Manually operated, front end "loaders", through to sophisticated and fully automated "surface reclaimers" are examples. If this approach can be justified, it should be used.

"Static Design" Technology can be applied by recognizing storage piles virtually have the same vertical flow characteristics as flat bottomed Bins and Silos (Figure 1). Consultants in this professional field can evaluate a sample and predict the vertical flow properties of many "Floodable" and "General" type bulk solids. A "shear test" is one of the trials conducted. This method relies upon the forces of gravity to cause the bulk solid to flow down through the ground level openings. An "Expanded" type vertical flow pattern is always wanted. It can be accomplished provided the required **"Critical Core"** dimension for the stored material is taken into account when determining the size of the opening. This makes it large enough to innately achieve the needed peripheral "sloughing" (Figure 2). Otherwise, only a "Funnel Flow" or "rat-hole" will probably occur. This is so regardless of the type of feeder installed under it, which includes those that vibrate. Another condition is any degree of "set" cannot be excessive. If the stored material is within the established limits of this concept, it is recommended that it be the choice.

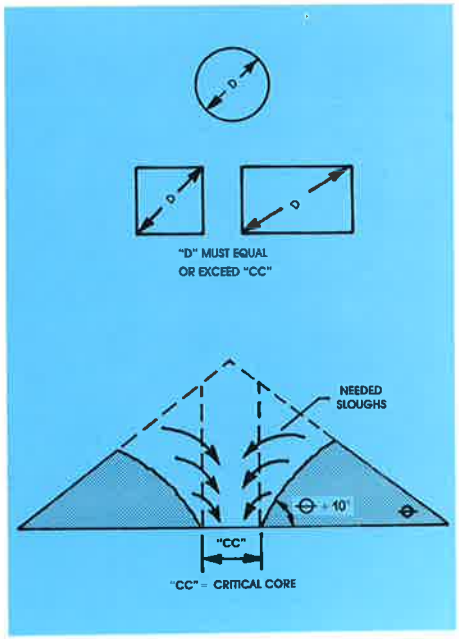


Fig. 2: The **"critical core" (cc)** dimension must be equaled or exceeded by the diagonal or diameter of the opening at ground level to achieve the needed "Expanded Flow". This is so even though a Bin Activator or Vibratory Feeder is installed "under" the opening.

"Induced Vertical Flow" is accomplished by the use of a vibratory machine that circumvents and inserts through the ground level opening. It is called a **"Storage Pile Discharger"**. Its vibratory action "induces" the stored material to vertically flow. Notice it is located "around and through" the open port as compared to being "under" it. Since a portion of this unit remains above the opening, it has continual contact with the pile. This feature is the reason it can "induce" the required peripheral "sloughing" of the stored material. Consequently, the needed "Expanded" type vertical flow pattern can be achieved. The extent of the "Expanded Flow" will approach the piled material's natural angle of repose.

This method should be pursued whenever the alternative of "Impelled Retrieving" is not preferred for some reason, and the limits of "Static Design" technology are exceeded. The latter typically occurs when one or more of the following are a factor:

1. It is impractical to comply with the required "Critical Core" dimension required in the ground level openings.

2. The vertical "flow properties" of the material are not reasonably consistent and vary too much.

3. A high degree of "set" is anticipated or ambient temperatures below "freezing" are expected.

4. The stored material is classified as being a "Flake" type.

Conclusion: If "Impelled Retrieving" is not employed, the two remaining methods must be designed to develop an "Expanded" type vertical flow pattern and adamantly avoid only a "Funnel Flow" core or so-called "rat-hole". This vertical channel reduces the amount of "live storage", and it is a potential safety hazard to operating personnel.

The Design of the Storage Pile Discharger

Description

The Storage Pile Discharger is essentially a Bin Activator equipped with a peripheral rim to ensure the needed "sloughing". It is driven by two motors instead of only one. The unit's design and dynamic force input configuration is purposely concentric and symmetrical to align with the "natural" phenomenon of the wanted "Expanded Flow" pattern of the stored material from the pile above.

Peripheral Rim: This so-called "drawdown skirt" projects above and around the ground level opening. It slopes outboard at 45° and it assures continual physical contact with the stored material. The vibration is transmitted into the pile above to induce the essential "sloughing" through its outer surfaces. This peripheral, outer rim distinguishes this vibratory machine from any other. Without it, the required sloughing from the surrounding edges of the active flow stream in the pile would not occur. It is the reason this unit alleviates the "Critical Core" dimensional requirement.

Uniform Side Wall Slope: The "conical transition" has a uniform slope of 60°. This angle is needed for a favorable vectorial resolution of the material's wall friction and the force input of the unit when it is on the "upstroke" or "lift" portion of its vibratory motion. The inherent "mass inertia" of the stored material opposing this upward motion helps to induce its downward movement from the pile and through the unit.

Internal Baffle: The internal "inverted cone" is the same type of baffle used in Bin Activators. It causes the full diameter of the unit's inlet to be the "first favored vertical flow stream". If "fines" inherently accumulate in the center of the pile, they are prompted to re-mix with the larger size flowing from the outer edges of the flow stream. By limiting its lateral clearance, it can act as a crude "scalping" means to prevent large lumps from blocking the unit's outlet. This practical situation occurs when the stored particles fuse together to form a high degree of "set" or when frozen material in the upper layers is encountered. Consequently, large chunks fall into the active flow stream as part of the "induced" peripheral sloughs from the pile.

Vibratory Drive System: Since gravity is the primary mover of the material, the "Single Input" or "Brute Force" type of vibratory drive system is utilized. It better fits the physical space limitation inherent in the unit's design. Its measure of "energy efficiency" is achieved by operating the unit in accordance with the natural flow characteristics of the bulk solid from the pile above.

Two motors that rotate eccentric weights are recommended because they will develop a "lift and twist" type of vibratory stroke action about the unit's vertical centerline. The dynamics are uniformly concentric and symmetrical. This matches the material's needed flow pattern. When wanted, units powered by only one motor will be supplied. If so, their lack of a full concentric and symmetrical vibratory action will have to be taken into account.

Liners: A liner to encourage the flow of the bulk solid through the unit is not necessary. Further, Storage Pile Dischargers suffer very little internal wear from the material passing through them, even though it may be highly abrasive. Conversely, mild steel surfaces can corrode over the long term. To avoid this, a sealed liner, which is typically 1/8" thick stainless steel 304, is recommended. It should cover all the internal surfaces and those of the peripheral rim.

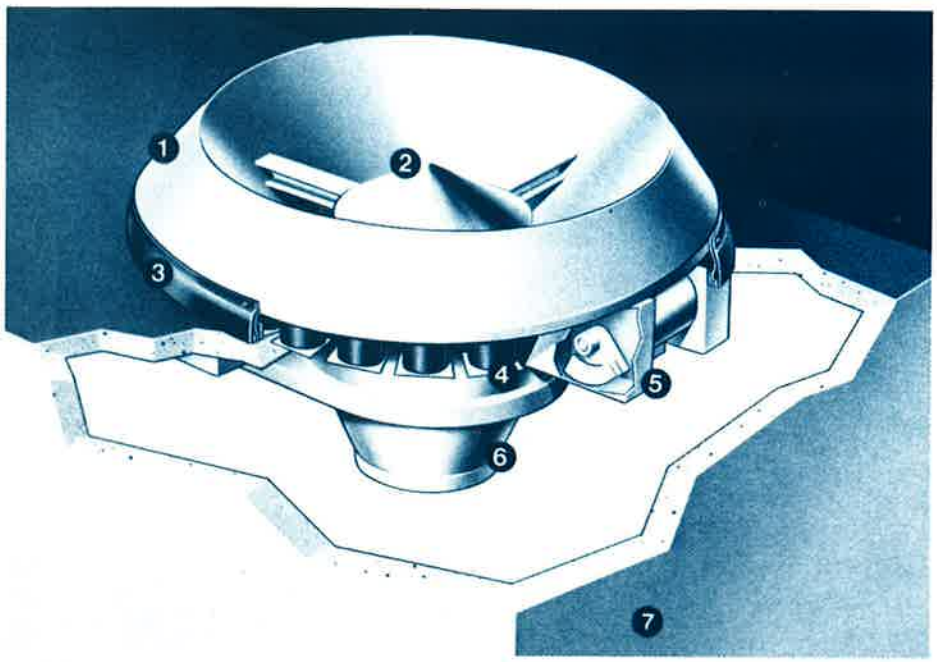


Fig. 3: Illustrates the Storage Pile Discharger and its typical installation.

1. The "peripheral rim" that acts as a "drawdown skirt" to ensure the required "sloughing" in the pile above.
2. The internal, conical baffle.
3. The inlet's flexible rubber connection. It consists of an inner sock secured by SS-304 bands, and it is protected by thick belting hanging over it from a bolting bar around the top.
4. Solid rubber isolators, which are normally not replaced for the life of the application.
5. One of the two vibratory motors with its rotating eccentric weights.
6. Outlet to a feeding device or the longitudinal conveyor.
7. The supporting concrete vault.

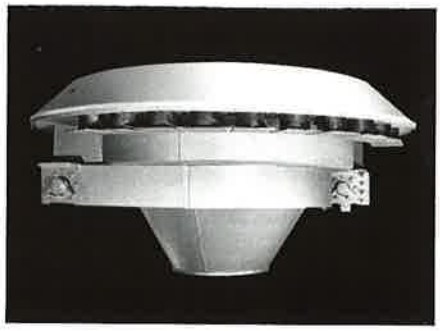


Fig. 4: The rubber isolators and eccentric weights of the two motors can be seen.

Available Units: Storage Pile Dischargers are available with drawdown skirts of 11, 13, and 15 ft. diameters, and if it is specifically needed, 18 ft. Their respective inlet diameters are 8, 10, 12, and 15 ft.

Operation; Expanding Flow from a Storage Pile

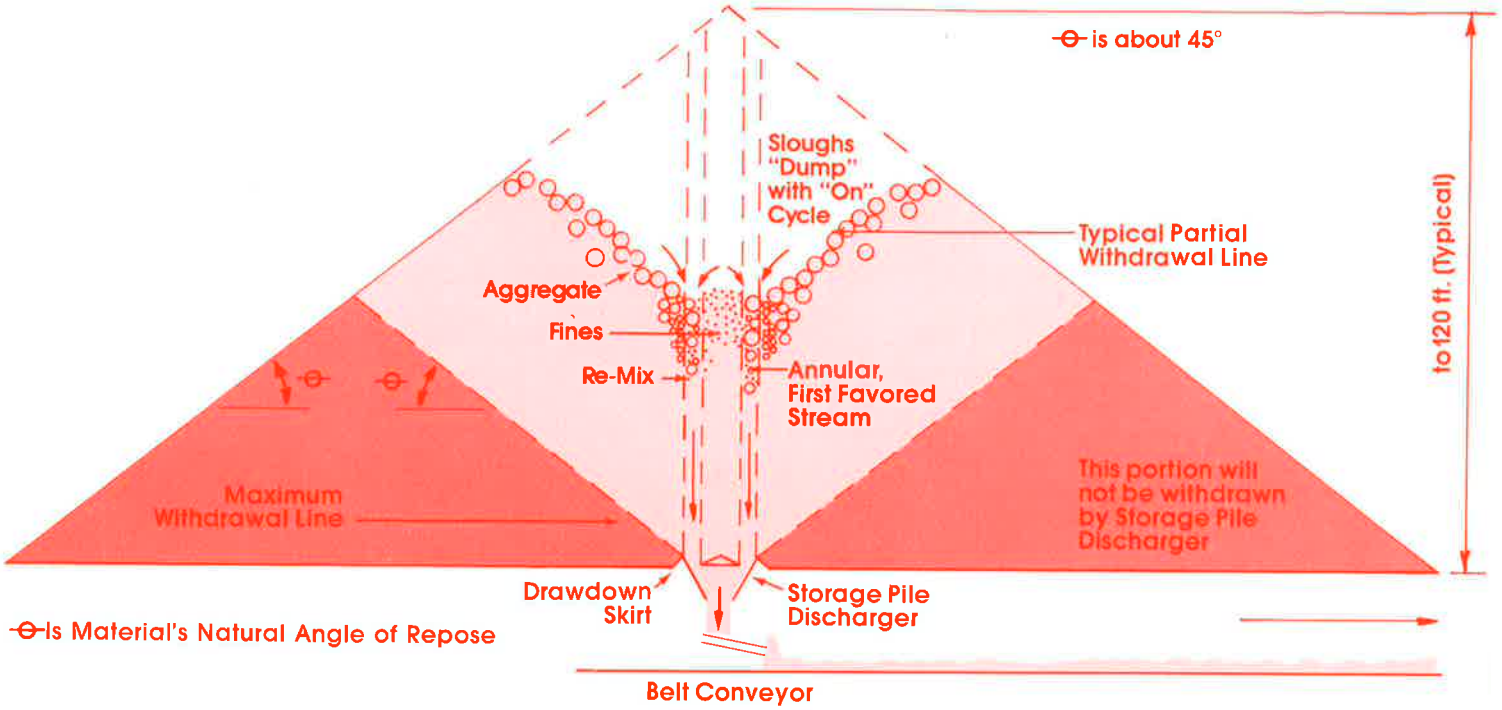


Fig. 5: Achieving an "Expanded Type Vertical Flow Pattern" from a storage pile.

Principle of Operation

The Storage Pile Discharger is buried under massive amounts of stored material. It is intended to remain that way for the life of the application.

Cycling: When the pile is to be discharged, it is vibrated with a "cycle type" of operation. The repetitive cycle is 15 seconds "on" and about 2 minutes "off". This can be automatically accomplished with an electrical timer. If the stored bulk solid has vertical flow properties that vary, it must be combined with a starve switch installed at the inlet of the feeder below. Since it is a more versatile performer, this is the preferred method of operation.

"Lift and Twist" Vibratory Motion: The Storage Pile Discharger generates a uniformly applied, symmetrical and concentric type of vibratory action that is transmitted up to the top of the pile. The operating frequency and the amount of stroke are selected to penetrate deep into the stored mass. The applied vibration reduces the material's combined "interparticle" shear strength, its friction with itself, and the inner walls of the unit. The large dynamic force

Fig. 6: A model SPD-15-HD Storage Pile Discharger. The O.D. of the peripheral rim is 15 ft., and its inlet is 12 ft. in diameter.

input "shatters" the fused bonding of particles which have taken a strong "set" or the upper layers that are frozen. It also unlocks the interweaving of "Flake" type materials. Consequently, the vibratory action "induces" the stored bulk solid to vertically flow, which includes the proper "sloughing", in conjunction with the forces of gravity.

Vertical Flow Pattern: Starting with a completely filled pile, the vertical flow stream will initially appear to be a "Funnel" type nearly equal in diameter to the unit's inlet. By turning the Discharger "on and off", the temporarily dormant material outside this active flow stream is not being packed or overly-densified by excess vibration. As this first favored flow channel descends, radial shear lines will begin to develop in the top layers of the storage pile that surround this flow stream. From above, these fractured lines of potential flow appear as large concentric circles all around the active channel. As the active stream drops further down, sloughs of material will begin to fall into it from around the top of its peripheral edges. These are induced to gently slide down into the active vertical flow stream by the vibratory action. As these peripheral sloughs slide in, the "Expanded" type of vertical flow pattern will emerge and become more defined. It will continue to move outward in ever-increasing concentric circles until the resulting crater's internal slope approaches that of the natural angle of repose for the stored material.

At this point, the pile can be refilled and the flow sequence repeated as shown in Figure 13.

The dormant material outside the limits of the Expanded flow pattern is usually retained as added storage for use as an emergency supply. Since this non-flowing section is repeatedly subjected to the vibratory action, it becomes "densified". This minimizes the possibility of any spontaneous combustion occurring if that is a consideration. When this material is needed, it can be safely reclaimed by a "loader" or any other means of "Impelled Retrieving".

▶ Installation
▶ Maintenance
▶ Benefiting Safety

Simple Installation

A concrete "vault" is the typical support for the Storage Pile Discharger. It is part of the longitudinal tunnel passing under the pile, which is usually constructed of concrete or corrugated steel.

The two 180° sections of the unit's mounting ring are placed around the opening and secured by anchor bolts (Figure 7). The rubber isolators are easily set by inserts engaging their center holes. Next, the unit is hoisted into position. The flexible connections are then installed around the unit's peripheral rim. Aside from the needed rigging, two workers most likely will complete the installation in less than one day.

Fig. 7: One-half of the mounting ring is shown. The isolators fit over inserts. The outer and upright vertical bar seals the bottom of the inner sock of the unit's inlet.

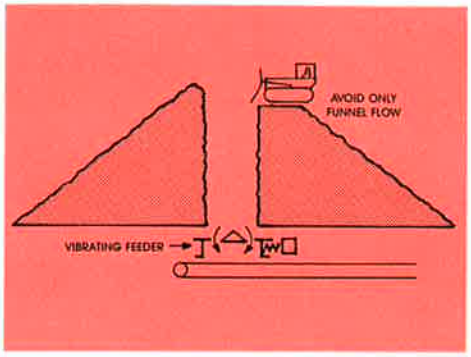


Fig. 8: When a storage pile has only "Funnel Flow", it can be a safety risk to a vehicle trying to push material into it.

Fig. 9: The mounting ring is the only item missing from this otherwise fully assembled unit.

Fig. 10: The "induced" Expanded Flow pattern of $-3/8$" size limestone from a conical pile 70 ft. in height. Note the internal slope of the crater nearly equals the angle of repose shown by comparing the slant of the outer surface to it.

Easy "Start-up"

The motor's eccentric weights are pre-set prior to the unit's shipment and seldom need changing. Only their correct rotation needs to be confirmed and possibly some minor adjustment to the cycle timer used in the motor's control circuit. Therefore, the "start-up" of a Storage Pile Discharger is easily accomplished.

Maintenance

Over the years, and for practical reasons, it has been realized these units receive very little routine maintenance attention. Their location over a tunnel, typically far removed from the active production areas, makes this understandable. Consequently, all the components of a Storage Pile Discharger are specifically designed for vibratory service, which virtually eliminates maintenance. All that's required is the occasional greasing of the vibratory motors, which are accessible from inside the tunnel.

There are no internal parts inside the Storage Pile Discharger that require routine maintenance.

Elimination of a Safety Hazard

When only a "Funnel" type flow channel discharges from the pile, it is a potential safety hazard. This is commonly called a "rat-hole". To achieve more reclaiming from the pile, a front-bladed tractor is often employed to push the dormant material into the gaping hole. Each time it does, the operator and the vehicle risk a peripheral "slough" collapsing in shear as it approaches the edge of the opening because of the added weight. If that happens, the vehicle will most likely fall down into the opening along with the huge amount of sloughing material (Figure 8).

In fact, it was an accident of this type that prompted the development of the Storage Pile Discharger in 1964.

The elimination of the potential safety hazard associated with only "Funnel Flow" or rat-holes is one of the finest attributes of a Storage Pile Discharger.

Energy Efficiency

Since the Discharger is always operated on a cycle, its "root-mean-square" or RMS power consumption is very low. It will be about one-fifth the HP rating of the motors driving the Discharger. For example, if the two motors have a total HP rating of 10, the actual "RMS" power being consumed would be about 2 HP. In comparison to the massive function being performed, that's "energy efficient".

Typical Applications

For a more detailed discussion of the alternatives and the application of this type of vibratory unit, refer to the technical bulletin entitled "The 'Induced Vertical Flow' of Storage Piles".

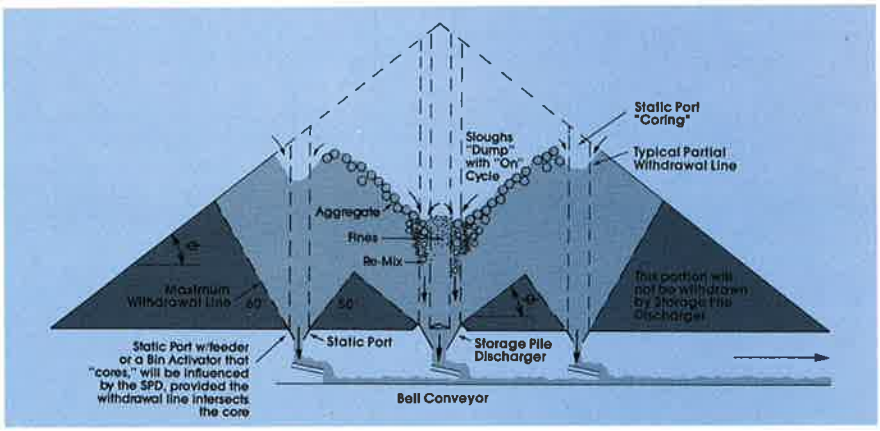


Fig. 11: The Funnel Flow "cores" emerging over adjacent "static ports" can be collapsed by the SPD's transmitted vibratory action, provided its "Expanded Flow" lines intersect them.

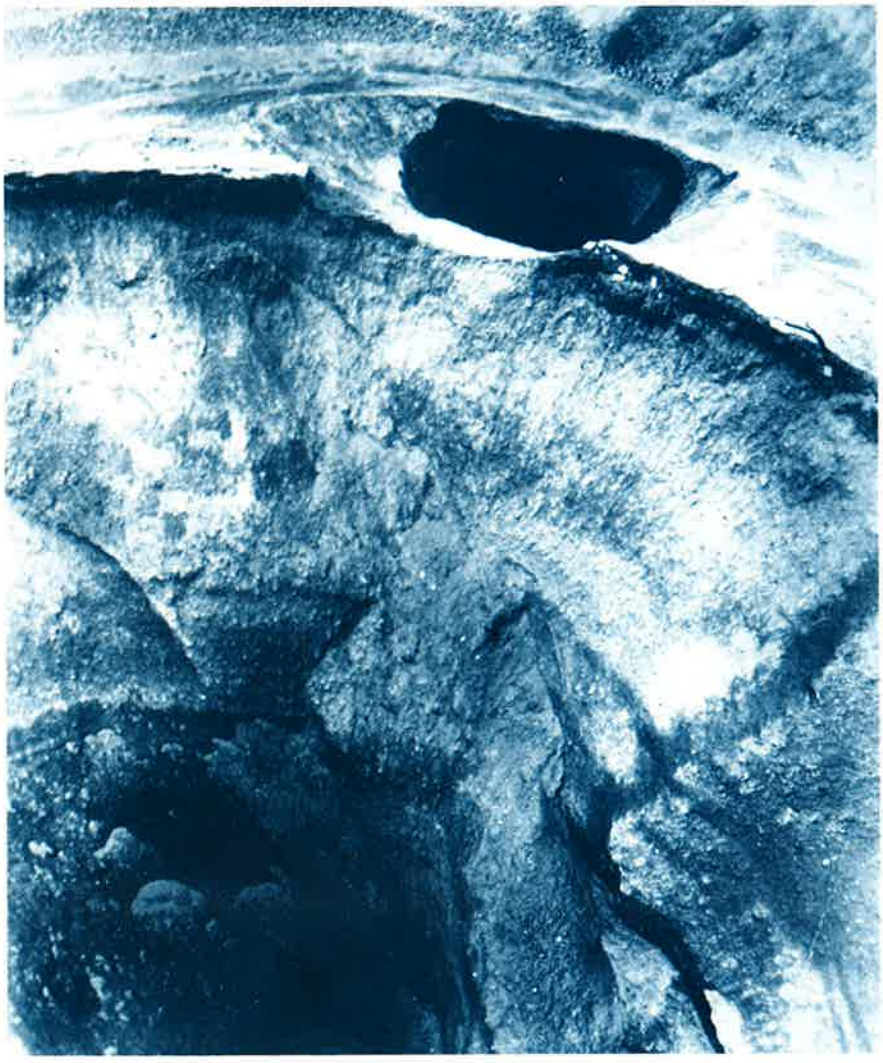


Fig. 12: A "Funnel Flow" rat-hole or core over a static port is about to be collapsed by the extension of the "Expanded Flow" crater in this pile, where a SPD "induces" the discharge of −2" size steam coal. The pile was initially 90 ft. in height.

Typical Applications

Storage Pile Dischargers can successfully "induce" the vertical flow of Flake, Floodable, and General type materials from all kinds of storage piles, with heights to 120 ft. This includes those which are Conical, Longitudinal, and so-called Kidney-shaped. The wanted "Expanded" vertical flow pattern can be achieved. Its final, internal slope angle of withdrawal from the pile is normally not more than 5° added to the natural angle of repose of the stored material. This discharging capability occurs even though the material has a high degree of "set", or exposed piles are subjected to seasons of heavy rain or ambient temperatures consistently below the freezing point. Examples of piled bulk solids being discharged are coal, lignite, trona ore, limestone, granite, sulfur, gypsum, potash, and wood chips.

On occasion, Storage Pile Dischargers can be retrofitted into existing, flat bottomed Bins and Silos to eliminate only "Funnel" type channels and change it to the wanted "Expanded" vertical flow pattern.

Static ports can be effectively used with a Storage Pile Discharger when the stored material will flow down through the opening in response to gravity. A "Funnel Flow" most likely will occur above them. The vibratory action transmitted by this unit will cause the core to collapse provided its "Expanded Flow" lines intersect the vertical channel standing above the ground level opening (Figures 11 & 12).

Fig. 13: When the extent of the "Expanded Flow" has been discharged, the pile is refilled. The peripheral, dormant material is usually left as extra storage and reclaimed only as an emergency supply.

Experience

The engineers of Kinergy have been intimately involved with the design, application, and operation of the Storage Pile Discharger since its inception in 1964. Kinergy is responsible for formulating the "Induced Vertical Flow" concept for discharging bulk solids from various types of storage means. Therefore, no supplier has more experience in this specialized field.

Expanded Flow Even in Adverse Weather

Fig. 14: Looking down into the crater of Expanded Flow. Both the size of the pile and the recent rain can be related by noting the trucks and the ground level water puddles standing in the top of photo. When the upper layers of the pile freeze, the desired Expanded Flow pattern will still be achieved. Note: The Storage Pile Discharger cannot be seen because it is buried under the pile of limestone; however, its effect on the pile is clearly visible!

Induced Vertical Flow
Induced Conveying

Kinergy's Many Vibratory Machines

The most complete line of vibratory machines for "inducing" bulk solid materials to vertically flow or convey.

Kinergy Corporation
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Louisville, Kentucky 40219
Phone: 502/366-5685
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Induced Vertical Flow: The vibratory action supplements the forces of gravity.

Discharging: The objective is a uniform, symmetrical and concentric vertical flow pattern.

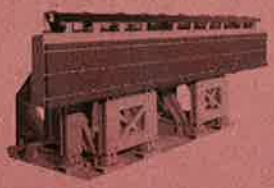

Bin Activator


Activated Bin


Container Activator


Sanitary Finishes


Storage Pile Discharger

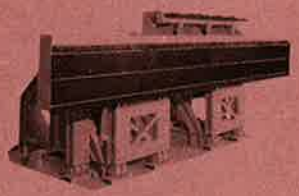

Rail Car Discharger

Densifying: Accomplishes "Inherent Densification" at the point of loading.


Tables


Container


Vertical Face


Rail Car Densifier

Induced Conveying: The intentional vibration is the prime mover of the bulk solid or unit pieces.

For the first time in the history of "Induced Conveying" machines, all these different units of various functions are powered by the same type of drive which inherently includes a full range of adjustable output by a simple method of electrical control.


Circular Feeder


Smallest: 2 by 15 inches


Largest: 12 by 38 feet

Unidirectional Feeders


Dust-Tight Trough


Dump Hopper


Primary Crusher Feeder


Polished Finishes


Sanitary Designs


Conveyor


Circular Conveyor


"Sizing" Screen


Deliquefying Screen


Drive on one end


Mixer


Fluidized Bed/Transferring Heat


Spiral Elevator


Shakeout Feeder


Shakeout Table


Attrition Mill/Sand Reclaimer