



Technical Paper T - 551



STOCKPILE SEGREGATION

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ABSTRACT

Material segregation is a problem that is inherent to most stockpiling techniques. As the demand for a higher quality product increases, the problem of stockpile segregation becomes more significant. Telescoping radial stacking conveyors are known to be the most effective solution for stockpile segregation. They are capable of creating a stockpile in layers, with each layer consisting of a series of windrows of material. In order to create a stockpile in this manner, the conveyor must be in motion almost continuously. Although the motion of a telescoping conveyor can be controlled manually, automation is by far the most effective method of control. An automated telescoping conveyor can be programmed to create customized stockpiles of many different sizes, shapes, and configurations. This nearly unlimited flexibility can add efficiency to an overall operation, as well as provide a higher quality product.

STOCKPILING

Each year contractors spend millions of dollars to produce aggregate products that are used for many different applications. Among the most popular applications are base material, asphalt, and concrete. The process of creating the products for these applications is very complex and costly. Tighter specifications and tolerances mean that the importance of product quality is becoming more and more significant.

There are many phases to the process of aggregate production. The virgin material must be stripped or blasted from its original location within the quarry. Once the material is removed from the mining surface, the process of reduction begins. The original material is first run through a primary crusher to reduce the product to a manageable size that can be handled by conveyors. Next, the material is run through a secondary crusher and possibly a tertiary crusher to reduce the product size even further. Along with the various crushing operations, the product is also passed through vibrating screens to sort it by particle size. Once the material has been sorted into different sized products, it is then ready to be stockpiled for storage. Eventually, the material is reclaimed from the stockpile and transported to a location where it will be incorporated into a road base, asphalt product, or concrete.

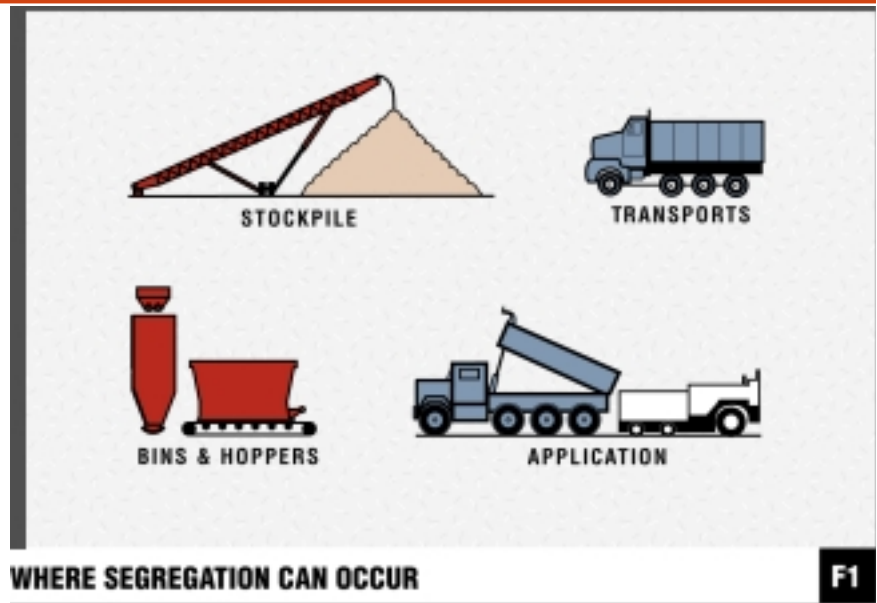
The equipment required for stripping, blasting, crushing, and screening is very expensive. However, today's equipment is capable of consistently producing aggregate material that is within specifications. Stockpiling may seem to be a trivial part of aggregate production; nevertheless, if done incorrectly, stockpiling can cause a perfectly "in spec" product to become out of spec. This is to say that some of the cost of creating a good product can be wasted by using poor stockpiling techniques.

Although placing product in a stockpile endangers its quality, stockpiling is a vital link in the aggregate production process. Stockpiling is a storage method that ensures material availability. The rate of production often differs from the rate at which the product is required for a given application, and stockpiles help to absorb this difference. Stockpiles also allow contractors sufficient storage to respond effectively to fluctuating market demands. Because of the benefits offered by stockpiling, it will always remain an important part of the aggregate production process. Therefore, producers must continually improve their stockpiling techniques in order to reduce the risks associated with stockpiling.

STOCKPILING PROBLEMS

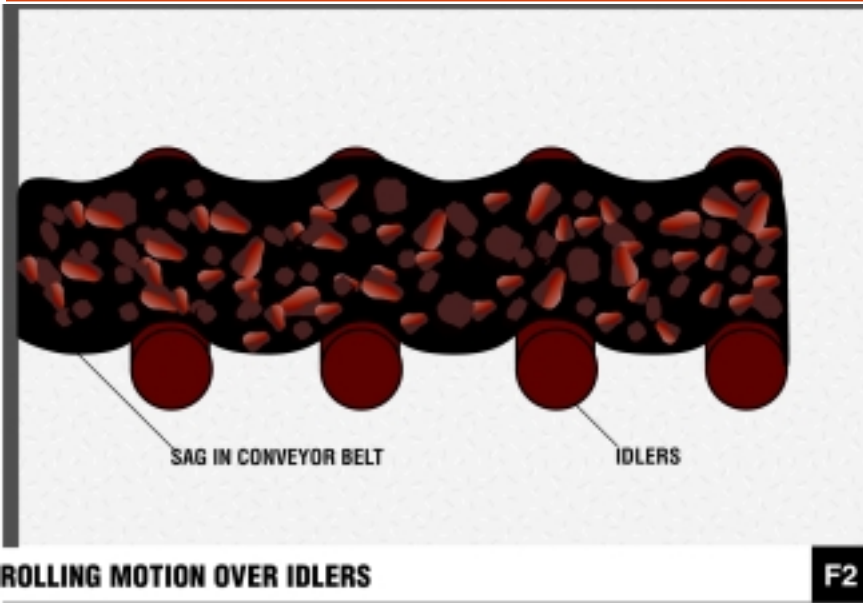
The three most common stockpiling problems are segregation, degradation, and contamination. The primary focus of this paper is on segregation. Segregation is defined to be “the separation of material by particle size.” Different applications of aggregate products require very specific and consistent gradations of material. Segregation causes excessive variation in the gradation of a product.

Segregation can occur virtually anywhere throughout the process of aggregate production after a product has been crushed, screened, and blended to its proper gradation. The first likely place for segregation to occur is within the stockpile (**Figure 1**). Once the material has been placed in the stockpile, it will eventually be reclaimed and transported to a location where it will be used. The second place that segregation can occur is during handling and transport. Once on site at an asphalt or concrete plant, the aggregate material is placed in feed hoppers and/or storage bins from which the product will be withdrawn and used. Segregation can also occur when hoppers and bins are filled and emptied. After the aggregate is blended into an asphalt or concrete mix, segregation can also take place during the application of final mix to a road or other surfaces. Segregation can be a problem in many different areas; however, the emphasis of this paper will be on causes and solutions for segregation within the stockpile (Figure 1).



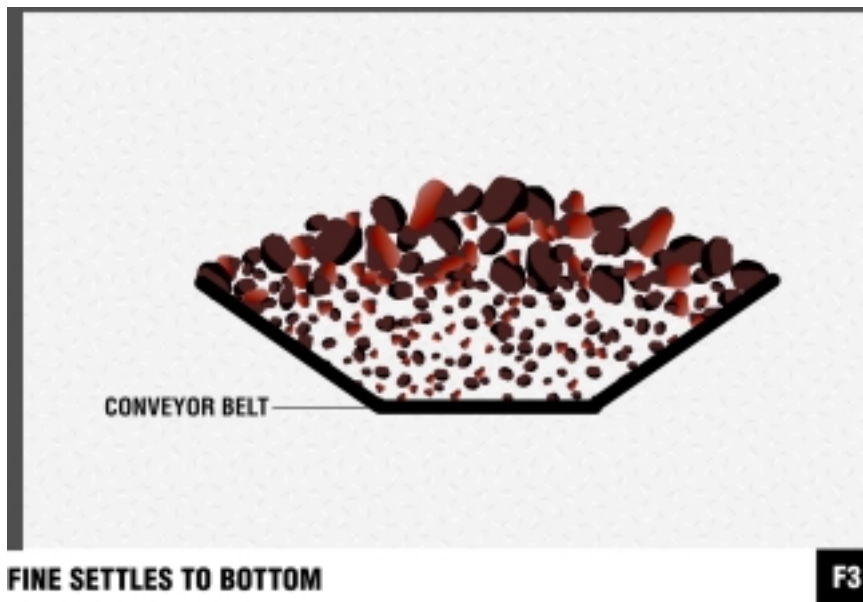
PROBLEMS CAUSED BY SEGREGATION

A uniform aggregate product is essential to producing high quality asphalt or concrete. The fluctuating gradation of a segregated aggregate product makes it nearly impossible to produce an acceptable asphalt or concrete product. A given weight of smaller particles has a larger total surface area than the same weight of larger particles. This presents a problem when combining the aggregate into an asphalt or concrete mixture. If the aggregate contains too high of a percentage of fines, there will be a shortage of concrete paste or asphalt, and the mixture will have an overly stiff consistency. If the aggregate contains too high a percentage of large particles, there will be an excess amount of concrete paste or asphalt, and the mixture will have a runny consistency. Roads constructed with segregated aggregate product will have poor structural integrity and, ultimately, a shorter life expectancy than those made from a properly desegregated product.

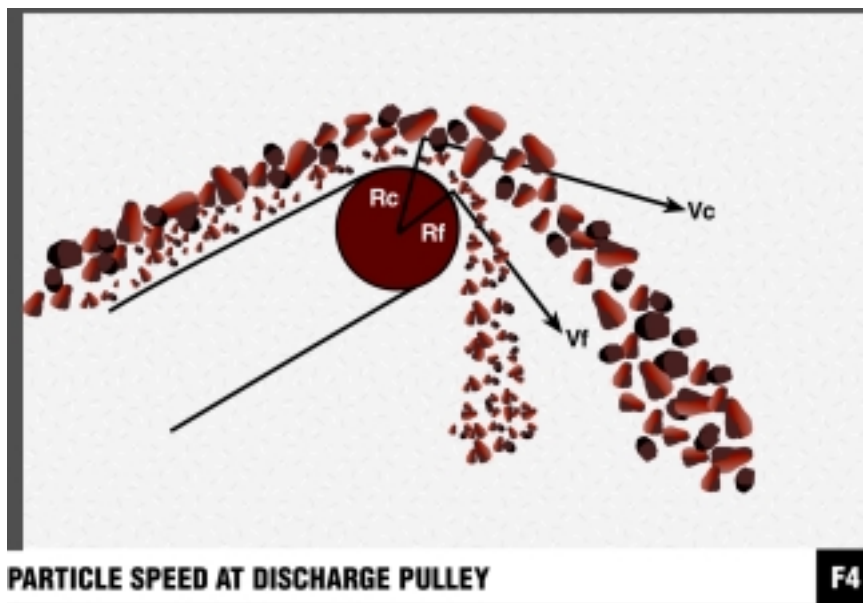


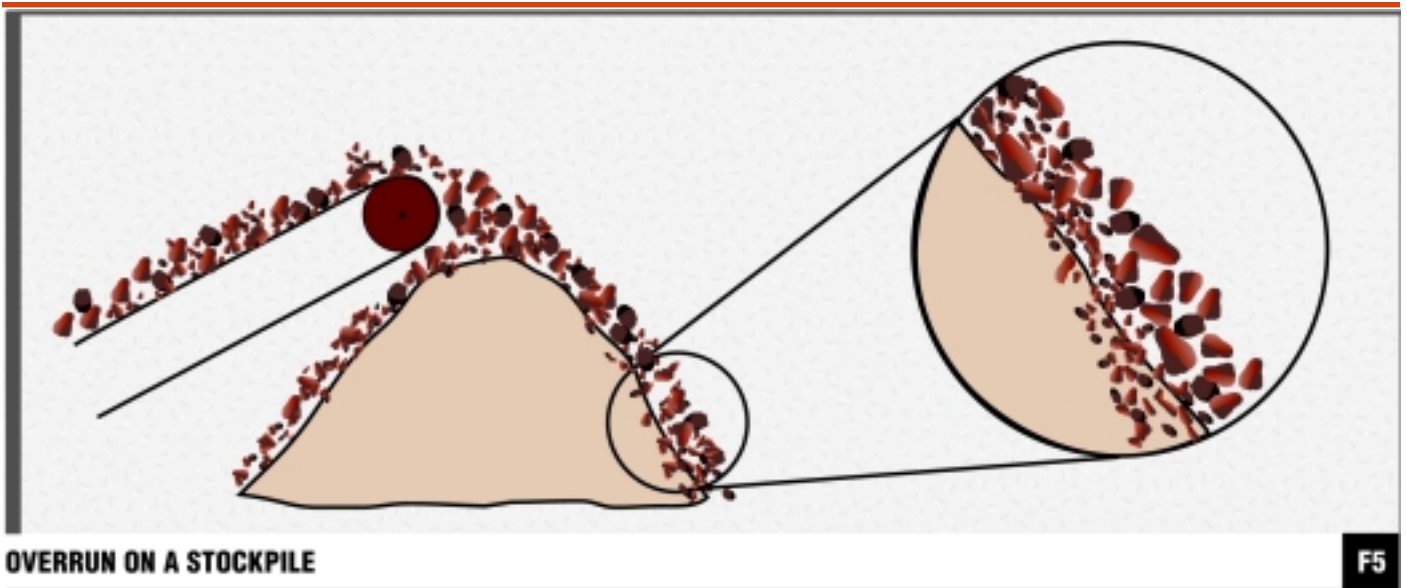
CAUSES OF STOCKPILE SEGREGATION

There are many factors that contribute to segregation within a stockpile. Since most stockpiles are created with a belt conveyor, it is important to understand the inherent effects of a belt conveyor on the gradation of a material. As a belt carries material along the conveyor, a slight bouncing motion is created by the belt rolling over the idlers (**Figure 2**). This is due to the slight sag in the belt between each idler. This motion causes the finer particles to settle to the bottom of the material cross section on the belt, and the coarser particles to stay on the top of the material cross section (**Figure 3**). Bridging of the coarse particles causes them to remain on top.

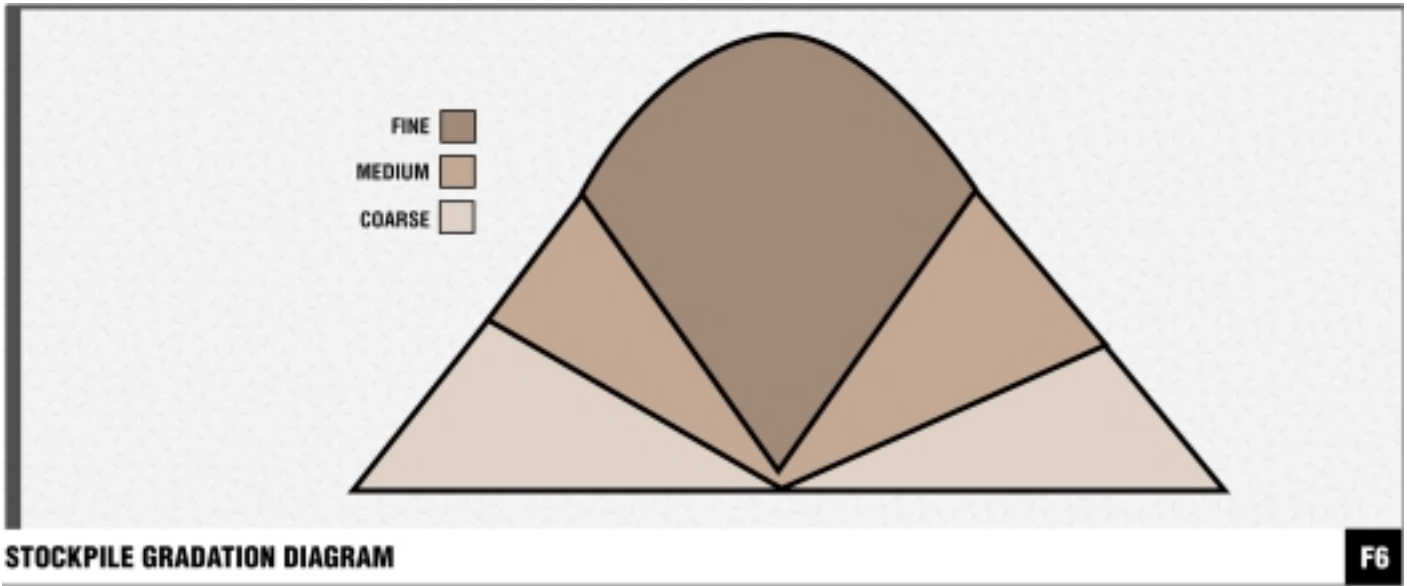


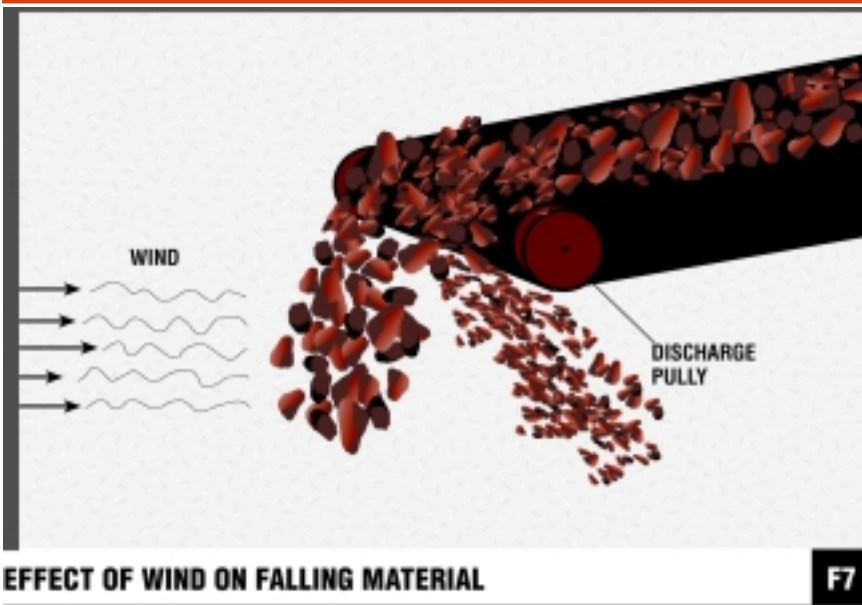
Once the material reaches the conveyor discharge pulley, it is already somewhat segregated with the coarser material on top and the finer material on the bottom. As the material begins to travel around the curvature of the discharge pulley, the top (outside) particles travel at a greater velocity than the bottom (inside) particles (**Figure 4**). This difference in velocity then causes the larger particles to travel farther from the conveyor before landing on the stockpile and the smaller particles to drop closer to the conveyor. Furthermore, the fine material has a greater tendency to cling to the conveyor belt and not be discharged until the belt has continued further around the discharge pulley. This causes even more fines to be pulled back to the front side of the pile.





When the material lands on the stockpile, the larger particles have a greater forward momentum than the smaller particles. This causes the coarse material to continue moving down the side of a pile more so than the fines. Any material, regardless of size, that cascades down the side of a stockpile is called overrun (**Figure 5**). Overrun is one of the leading causes of segregation in a stockpile and should be avoided if at all possible. As overrun begins to tumble down the slope of a pile, the larger particles tend to roll down the entire length of the slope while the finer material tends to settle into the side of the pile (Figure 5). Therefore, as overrun proceeds down the sides of a pile, fewer and fewer fines remain with the tumbling material. When the material reaches the bottom edge, or toe, of the pile, it consists primarily of the larger particles. The effect of overrun causes a pronounced segregation that is visible in a section view of a stockpile (**Figure 6**). The outer toes of the pile consist of the coarser material, while the inner and upper portions of the pile consist of more fines. Particle shape also contributes to the effects of overrun. Particles that have a smooth or round shape are more likely to roll farther down the slope of a pile than crushed particles that typically have a boxier shape. Overrun can also cause material degradation. As the particles tumble down the side of the pile, they rub against each other. This abrasion can erode some of the particles into smaller sizes.

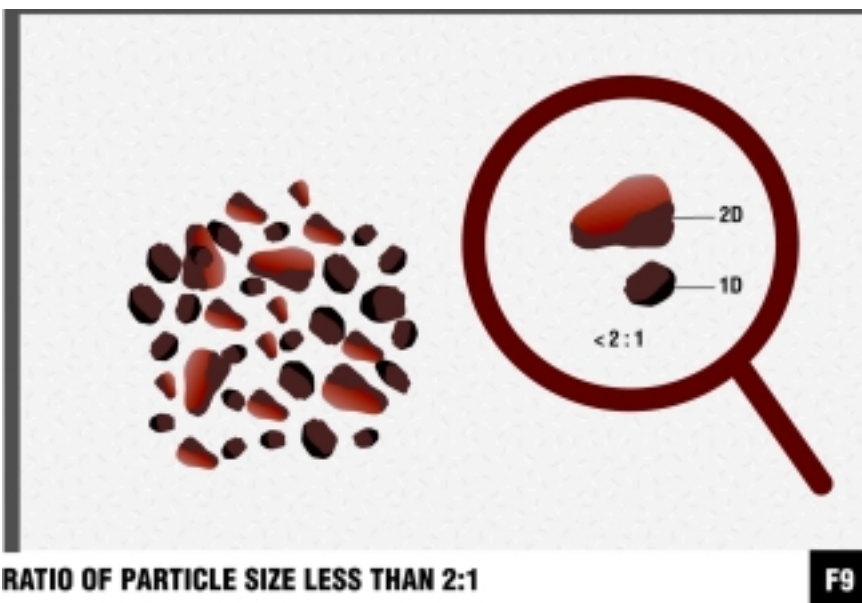
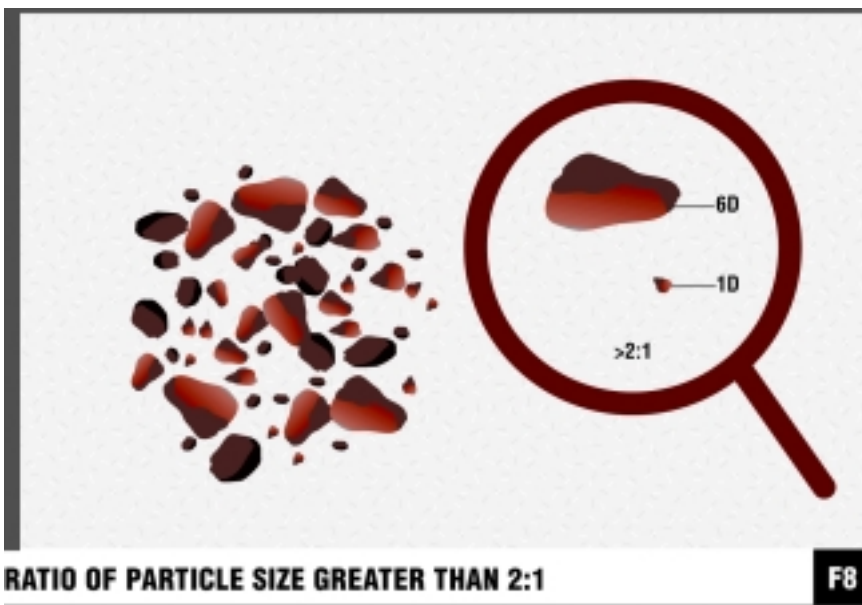




Wind is another cause of segregation. After material leaves the conveyor belt and begins its descent to the stockpile, wind will affect the trajectory of different size particles. Wind has a great effect on fine material but little or no effect on larger material (**Figure 7**). This is due to the fact that the surface area-to-weight ratio is greater for small particles than it is for large particles.

WHEN IS STOCKPILE SEGREGATION A PROBLEM?

The potential for segregation within a stockpile may vary depending on the type of material being stockpiled. The most significant factor related to segregation is the degree of variation of particle size within the material. Materials with a greater variation in particle size will have a higher degree of segregation when stockpiled. A general rule of thumb is that if the ratio of the size of the largest particles to the size of the smallest particles exceeds 2:1, stockpile segregation is likely to be a problem (**Figure 8**). On the other hand, if the ratio of the particle sizes is less than 2:1, stockpile segregation will be minimal (**Figure 9**). For example, a road base material which contains $\frac{3}{4}$ " particles all the way down through 200 mesh particles is likely to segregate when stockpiled. However, segregation will be insignificant when stockpiling a product such as $\frac{3}{4}$ " washed stone. Sand can usually be stockpiled without a segregation problem due to the fact that most sand is produced wet. The moisture causes the particles to cling together, preventing segregation.



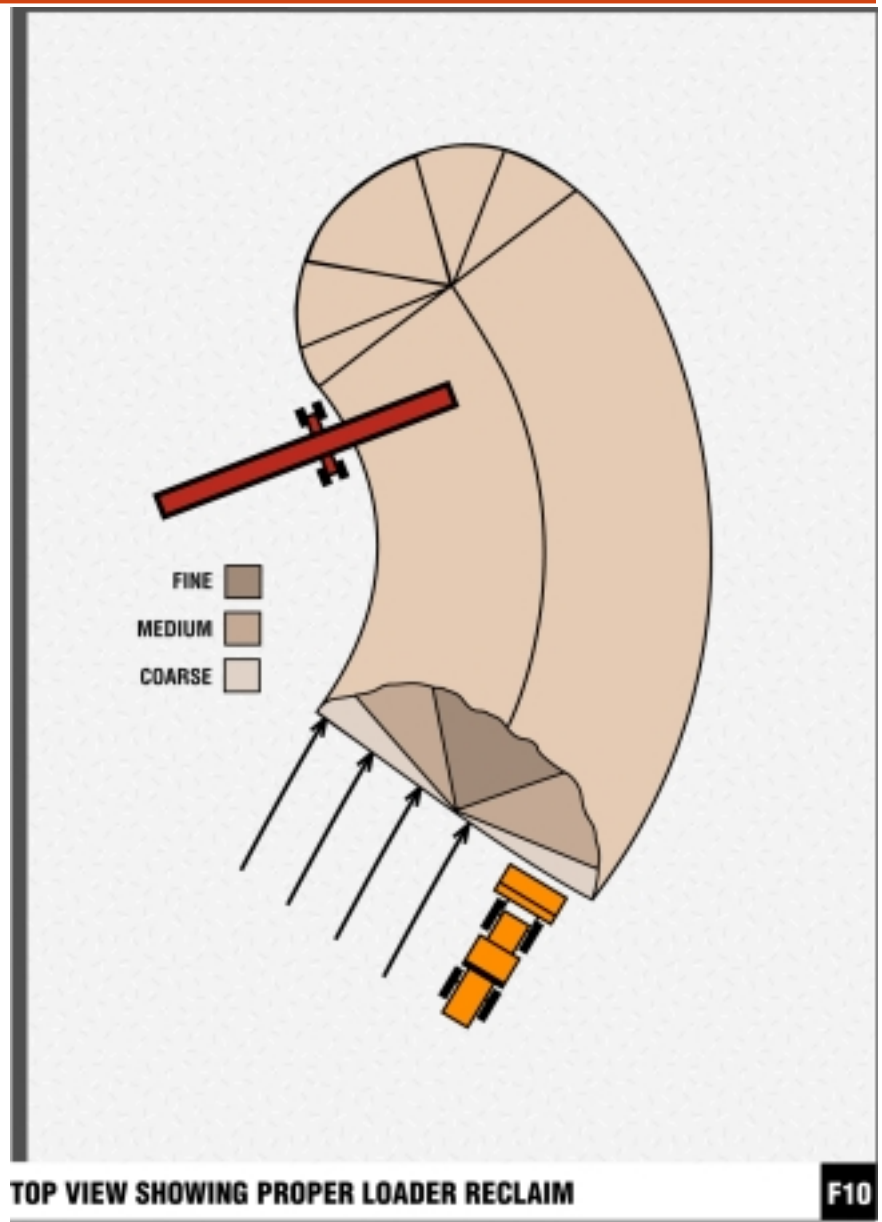
DEALING WITH SEGREGATION

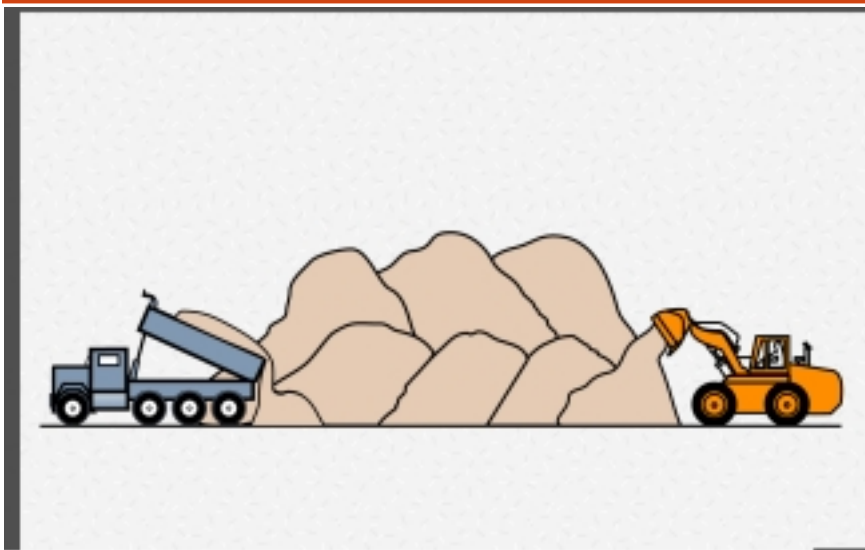
There may be times in which segregation was not prevented when the product was stockpiled. The outside edges of a finished pile consist primarily of coarse material and the inner portion of the pile has a higher concentration of fines (Figure 6). When reclaiming from the end face of this type of pile, scoops must be taken from various locations in order to blend the material (Figure 10). Reclaiming only from the front face or back face of the pile will result in all coarse material or all fine material.

There is also an opportunity for further segregation when loading a truck. It is important that the method used does not result in overrun. The front of the truck should be loaded first, then the back, and finally the middle. This will minimize the effect of overrun within the truck.

PREVENTING SEGREGATION

Methods of dealing with segregation after the building of a stockpile are useful, but the goal should be to prevent or minimize segregation as the stockpile is made. Mixing the stockpile, building the stockpile in layers, telescoping conveyors, variable height conveyors, radial travel conveyors, rock ladders, telescoping chutes, and paddle wheels are all useful in the prevention of segregation.

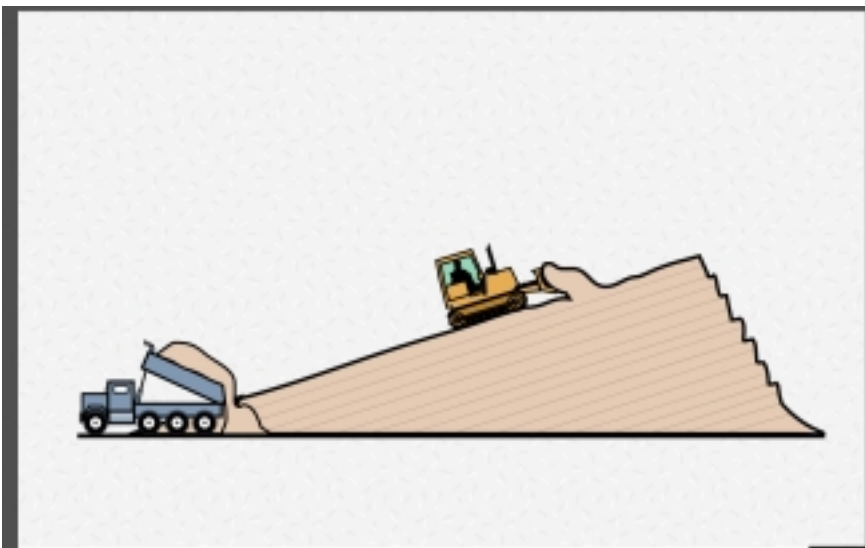




STOCKPILING WITH LOADER AND TRUCK

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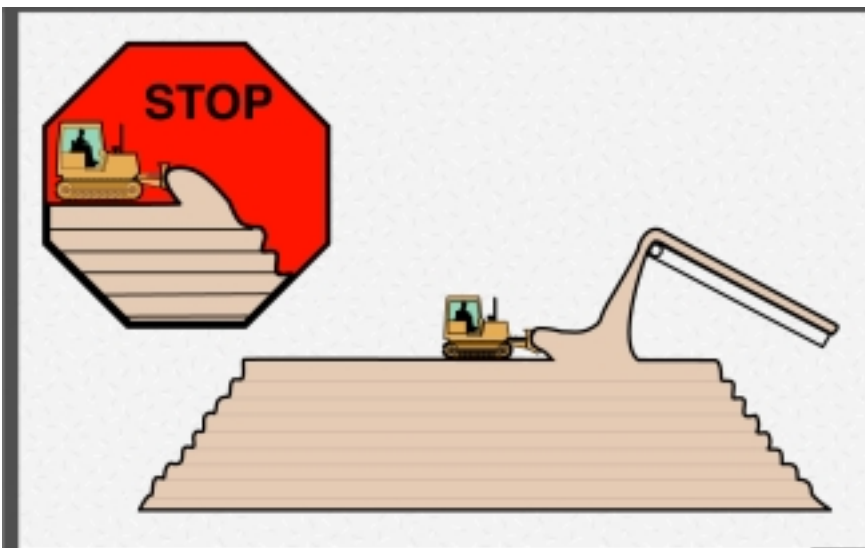
When building a stockpile with a truck, care should be taken to dump into separate piles to minimize overrun (**Figure 11**). A loader should be used to push the pile together by raising the material to full bucket height and dumping, which will blend the material. Building larger piles should not be attempted if it requires the loader to drive on and degrade the material.



STOCKPILING WITH DOZER AND TRUCK

F12

Building the stockpile in layers can minimize segregation. This type of stockpile can be built with the aid of a dozer (**Figure 12**). If material is brought to the stockpile with a truck, the dozer should push the material into inclined layers. If the stockpile is built with a conveyor, the dozer should push the material into horizontal layers (**Figure 13**). In either case, care should be taken not to push material over the edge of the pile. This results in overrun, which is one of the leading causes of segregation.



STOCKPILING WITH CONVEYOR AND DOZER

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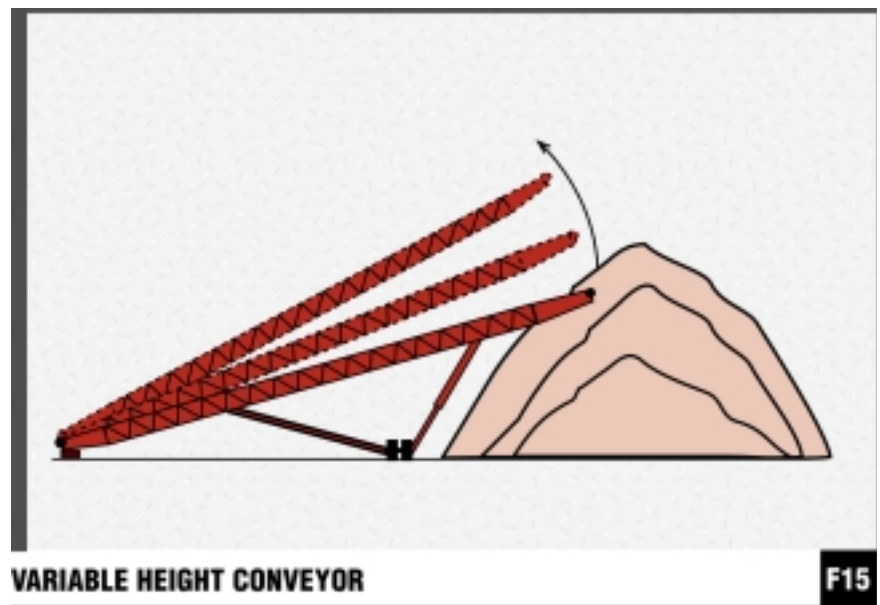
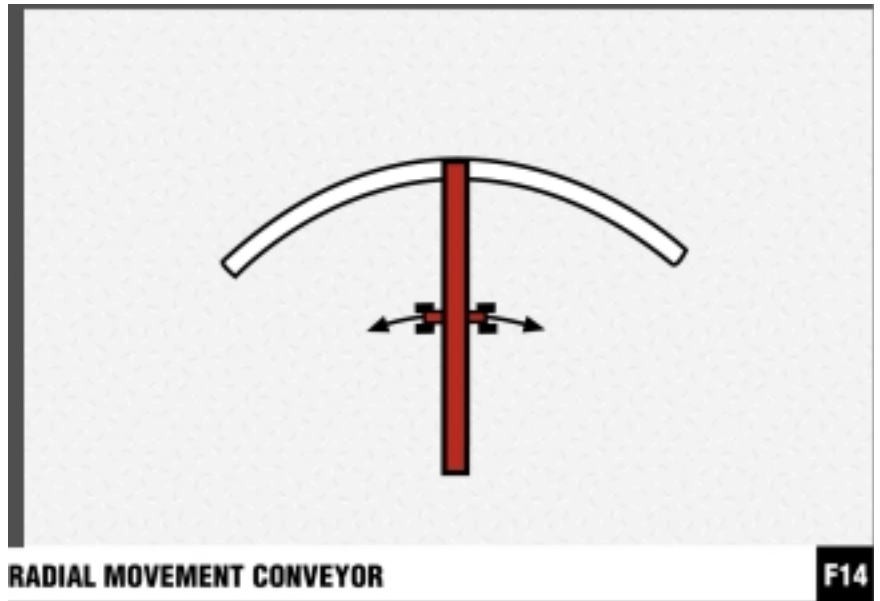
There are several disadvantages to making a stockpile with a dozer. Two significant risks are degradation and contamination of the product. Heavy equipment continuously running over the product will compact and crush the material. Using this method, producers must be careful not to degrade the product too much in an attempt to alleviate the segregation problem. The extra labor and equipment required often make this method cost prohibitive and results in producers settling for methods of dealing with segregation upon reclaim.

A radial stacking conveyor will help minimize the effects of segregation (**Figure 14**). As the stockpile is being built, the conveyor moves left and right radially. The end toe of the pile, which is normally coarse material, will be covered with fine material as the conveyor travels radially. The front and back toe will still be coarse material, but the stockpile will be blended more than a conical pile.

There is a direct relationship between the height of free fall of material and the degree of resulting segregation. The fines are separated more and more from the coarse material as the height increases and the trajectory of falling material widens. Therefore, variable height conveyors are another method of minimizing segregation (**Figure 15**). During the initial stages, the conveyor should be in the lowest position. The distance from the head pulley to the pile should always be minimized.

Free fall from the conveyor onto the pile is another cause of segregation. A rock ladder will minimize segregation by eliminating the free fall of the material. A rock ladder is a structure that allows the material to flow down a series of steps onto the pile. This is effective, but has limited application.

Segregation caused by wind can be minimized with a telescoping chute. A telescoping chute at the discharge pulley of a conveyor that extends from the pulley to the pile will shield the wind and limit the effects of it. If designed correctly, it can also limit free fall of material.



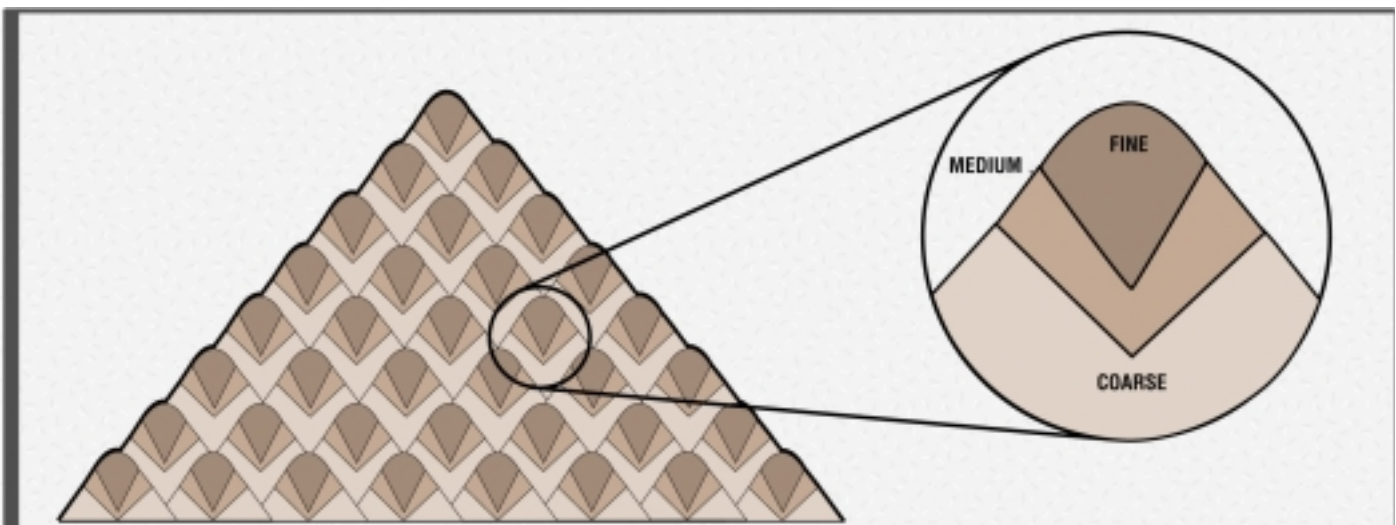
As discussed previously, there is already segregation on the conveyor belt prior to reaching the discharge point. Also, further segregation occurs as the material leaves the belt. Paddle wheels may be installed at the discharge point to re-blend this material. The rotating wheel has wings or paddles on it that intersect and agitate the trajectory of material. This will minimize segregation, but the material degradation may not be acceptable.

Significant costs may be incurred as a result of segregation. Out-of-spec piles may lead to penalties or rejection of entire stockpiles. If out-of-spec material is delivered to a job site, the penalty may be in excess of \$0.50/ton. The labor and equipment cost to rebuild an out-of-spec pile is often cost prohibitive. The cost per hour of using a dozer and operator to build the stockpile is higher than that of an automated telescoping conveyor, and the material may be degraded or contaminated in the effort to maintain the proper gradation. This will decrease the value of the product. In addition, there is an opportunity cost associated with using equipment such as a dozer for a non-production task when it has been capitalized for a production task.

THE WINDROW CONCEPT

When creating a stockpile in an application where segregation can be a problem, another method can be used to minimize the effects of segregation. This involves making a stockpile in layers, with each layer consisting of a series of windrows (Figure 15). In a section view of a windrow stockpile, each windrow appears as a miniature pile (Figure 16).

Segregation still occurs within each individual windrow from the same effects discussed earlier. However, the segregation pattern is repeated more often throughout the cross section of the pile. Such a pile is said to have a greater “segregation resolution” because the segregated gradation pattern repeats itself more often in smaller intervals. When reclaiming a windrow pile with a front-end loader, there is no need to blend the material because one scoop includes several windrows (Figure 17). As a windrow pile is being reclaimed, the individual layers are clearly visible (Figure 18).



SEGREGATION RESOLUTION IN A WINDROW PILE

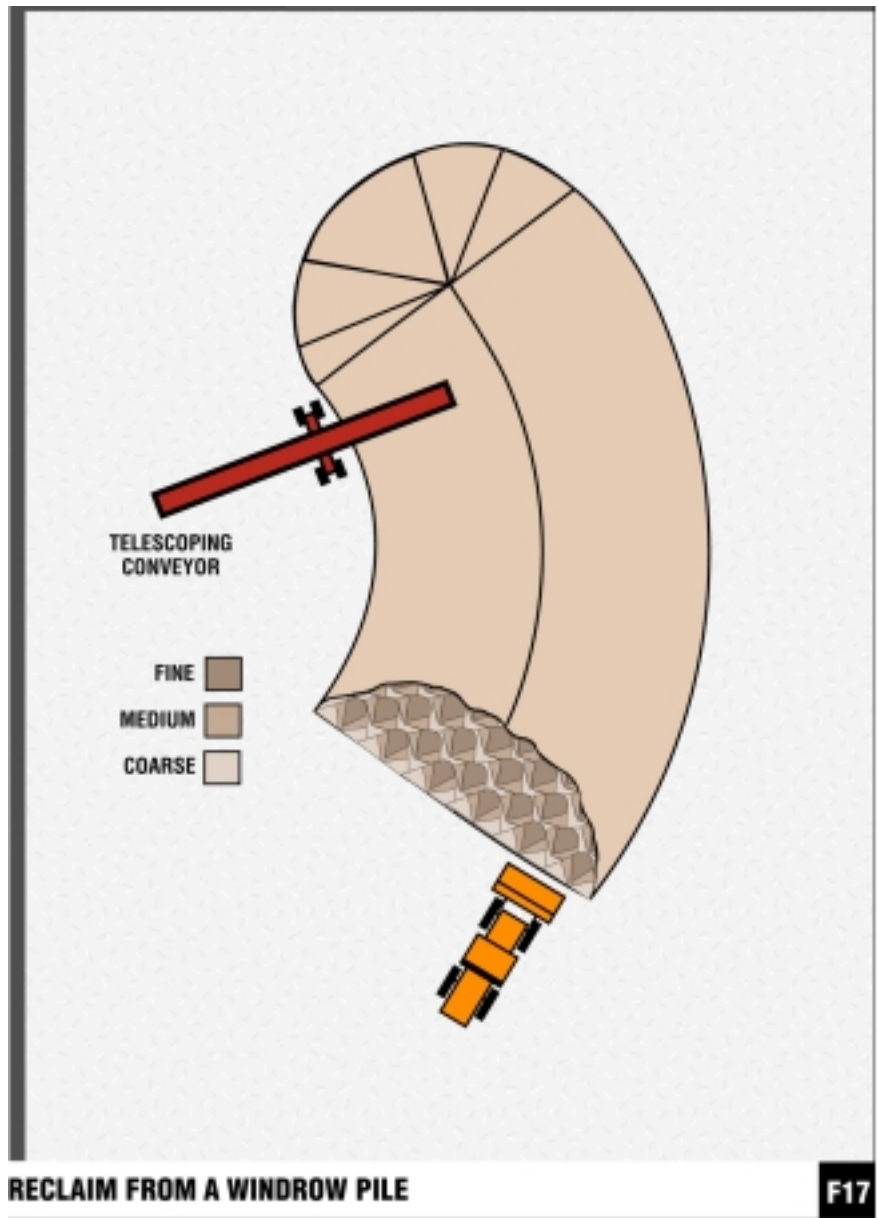
F16

Windrows can be created using different techniques of stockpiling. One method is to use a bridge and tripper conveyor system, though this alternative is feasible only for stationary applications. One significant disadvantage of stationary conveyor systems is that they are typically fixed in height, which can result in segregation by wind as discussed earlier.

Another method is to use a telescoping conveyor. Telescoping conveyors are typically preferred over stationary systems because they can be relocated when necessary, and many are actually designed to be road-portable (Figure 19).

TELESCOPING CONVEYORS

The most effective way to build a windrow stockpile is by using a telescoping conveyor. The telescoping conveyor consists of a conveyor (stinger conveyor) mounted inside an outer conveyor of similar length (Figure 20). The stinger conveyor has the ability to move linearly along the length of the outer conveyor, thereby varying the location of the discharge pulley. The height of the discharge pulley is variable as well as the radial position of the conveyor. The three-axis variation of the discharge pulley is essential in making the layered pile that overcomes segregation.





TELESCOPING CONVEYOR READY FOR TRANSPORT

F19

A cable winch system is often used to extend and retract the stinger conveyor. The radial movement of the conveyor may be driven by a chain and sprocket system or hydraulic powered planetary drives. The height of the conveyor is often varied via cylinders that extend a telescoping undercarriage system. All of these movements must be controlled in order to build a layered pile automatically.

The telescoping conveyor has the mechanisms in place to build a completely layered pile (**Figure 21**). Minimizing the depth of each layer will help to limit segregation. This requires the conveyor to be moving constantly as it

builds the stockpile. The need for constant movement makes automation of the telescoping conveyor essential. There are several different methods of automation, some of which are less costly with significant limitations, while others are fully programmable and offer much versatility when building a stockpile.

One method of automation includes limit switches that control the motion of the conveyor. As the conveyor begins to build the stockpile, it moves in a radial direction while conveying material. The conveyor moves until a limit switch mounted to the axle of the conveyor is tripped by a trigger that is in its radial path. This trigger is placed according to the length of the arc the operator wants the conveyor to travel. At this point the stinger conveyor extends a predetermined distance and starts traveling in the other direction. This process continues until the stinger conveyor has been extended out to its maximum extension and the first layer is complete (**Figures 22 & 23**).

When the second layer is built, the stinger begins retracting from its maximum extension, traveling radially and retracting at the arc limits. Layers are built until a tilt switch mounted at the discharge pulley is activated by the pile.



TELESCOPING CONVEYOR

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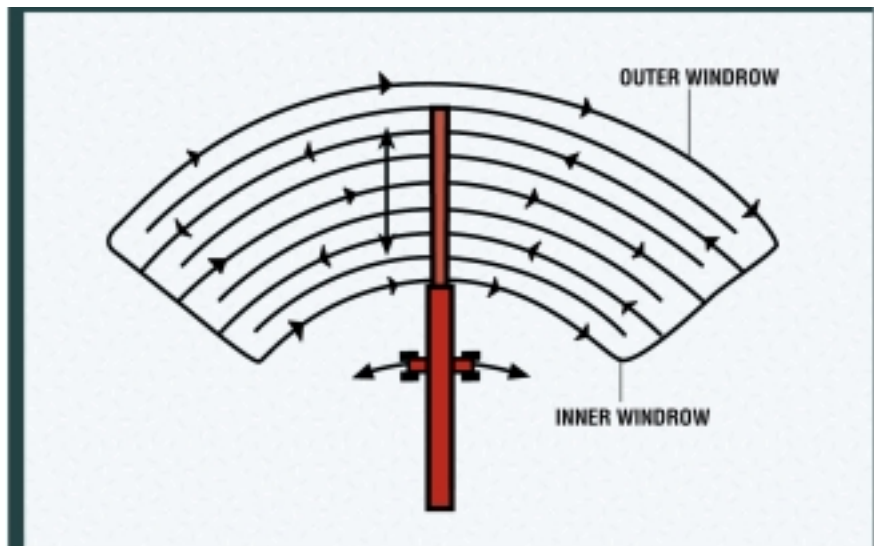
The conveyor will raise a predetermined distance and begin its second lift. Each lift may consist of several layers, depending on the rate at which the material is being conveyed. The second lift is built similar to the first lift and so on until the entire pile is built. A large part of the resulting pile is de-segregated; however, there is overrun on each edge of the pile. This is because the conveyor cannot automatically adjust the limit switches or the location of the objects used to trip them. The retract limit switch must be adjusted so the overrun does not bury the conveyor axle. Another limitation deals with the fact that it takes the same amount of time to travel the outer arc as the inner arc (Figure 21). Since the outer windrow is much longer than the inner windrow, the rate the discharge pulley moves with respect to the ground is much faster on the outer windrow than the inner windrow. Assuming constant conveying capacity, the layer will be higher on the inner arc than the outer arc (Figure 24).

Another method of automation consists of utilizing a programmable logic controller (PLC) to control operations of the conveyor. A PLC is a computer that receives data from input devices and processes this data to control the operation of various components. An encoder can be mounted to the winch that extends and retracts the stinger conveyor. As the conveyor extends or retracts, the PLC is aware of the exact location of the stinger conveyor, making its movements programmable. The extension and retract limits of the stinger can be automatically changed for each layer. By making each subsequent layer narrower, overrun can be eliminated (Figure 24). The retract limit can be adjusted so the axle does not get buried by overrun. The extend increments can be shortened as the conveyor approaches the outer arc. This will result in a level pile at constant conveying capacity (Figure 25).



WINDROW STOCKPILING WITH A TELESCOPING CONVEYOR

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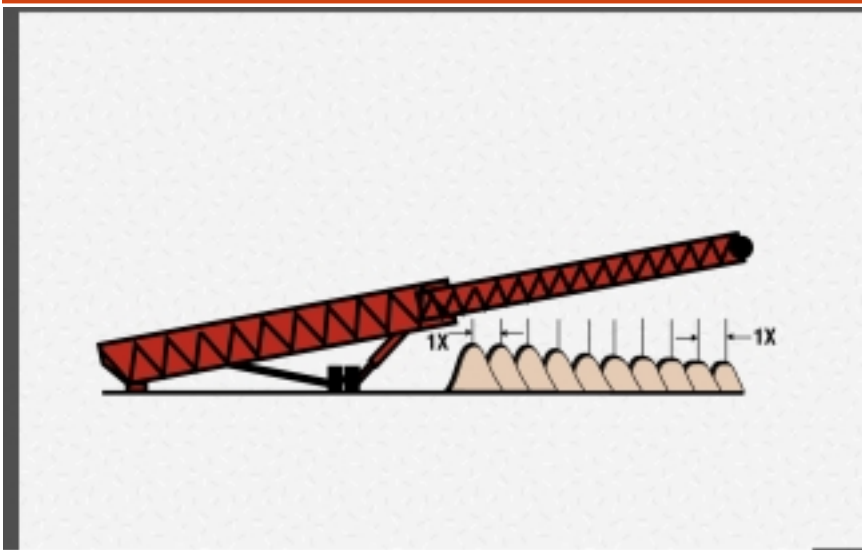
WINDROW CONFIGURATION

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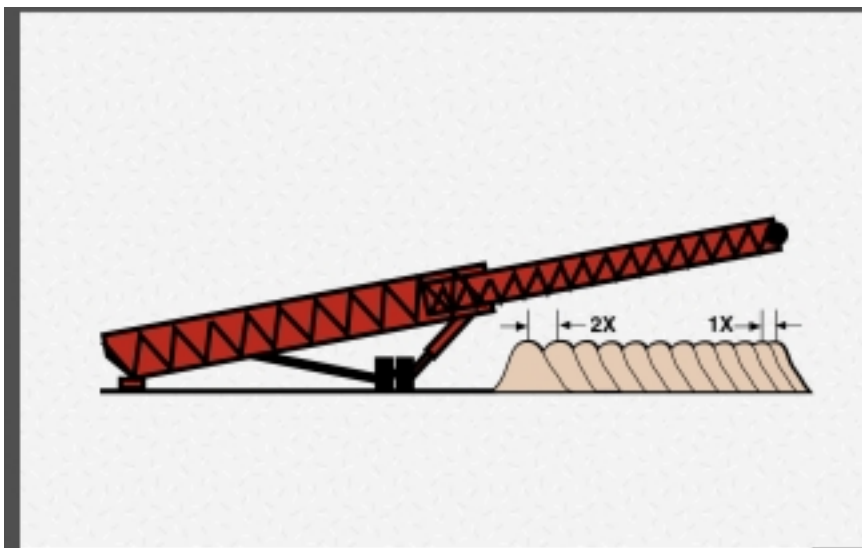
CREATING WINDROWS WITH A TELESCOPING CONVEYOR

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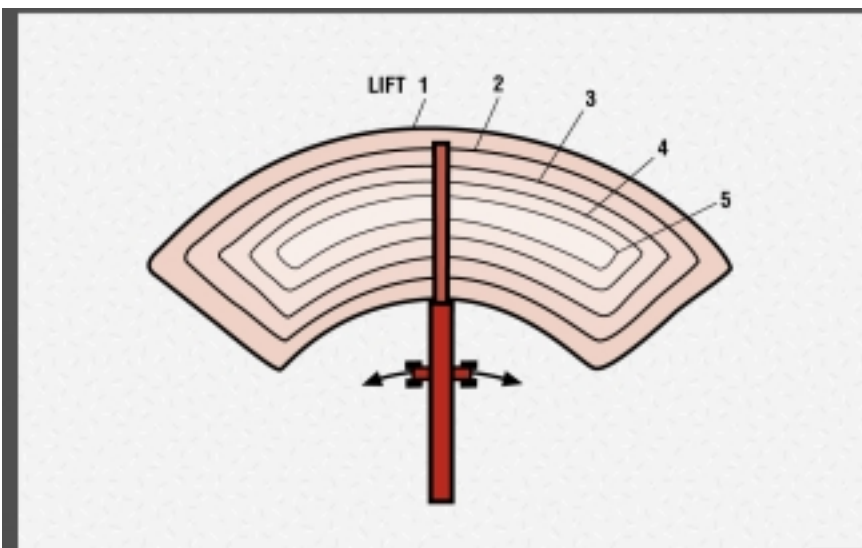
WINDROW HEIGHT DECREASES TOWARD OUTER ARC

F24



HEIGHT OF WINDROWS REMAINING CONSTANT

F25



TOP VIEW OF DESEGREGATED PILE

F26

An encoder can also be mounted to one of the wheels of the conveyor to monitor the radial position of the conveyor. The encoder for the radial travel does not rely on off-board devices to activate switches. Instead, the encoder is self-contained and can be programmed to adjust the arc limits to eliminate overrun on the ends of a pile (**Figure 26**).

A tilt switch is mounted at the discharge point on the stinger conveyor to indicate at what point the conveyor must raise to the next lift. This ensures that the conveyor will raise before burying the discharge pulley in the pile. Some automation packages allow the tilt switch to indicate when to move one radial increment, rather than travel continuously, which gives the ability to build a desegregated pile when conveying capacity is not constant.

This method of automation lends itself to customized automation packages. The arc pile is by far the most common (**Figure 21**). The arc pile is built of windrows that are concentric to the conveyor feed point. In certain situations, it is advantageous to customize the program. At some job sites, it is more convenient to load-out parallel to the conveyor. In this case an inline pile would be desired (**Figure 27**). The inline pile is built of windrows that are radial to the conveyor feed point. It is a small matter to program the telescoping conveyor to build this type of a stockpile. Unusual site layout or lack of real estate could be reasons to choose a rectangular pile (**Figure 28**). In each instance, proper reclaiming methods are not compromised.

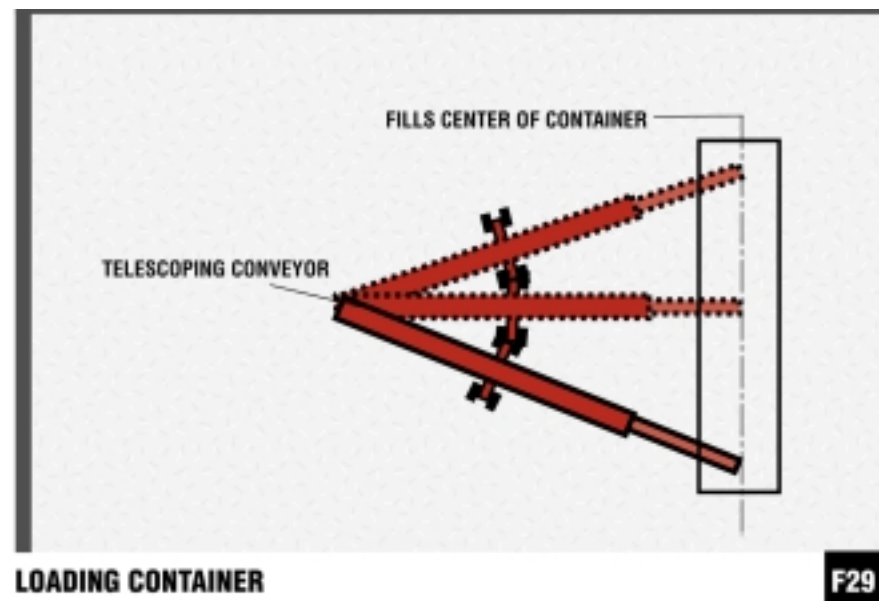
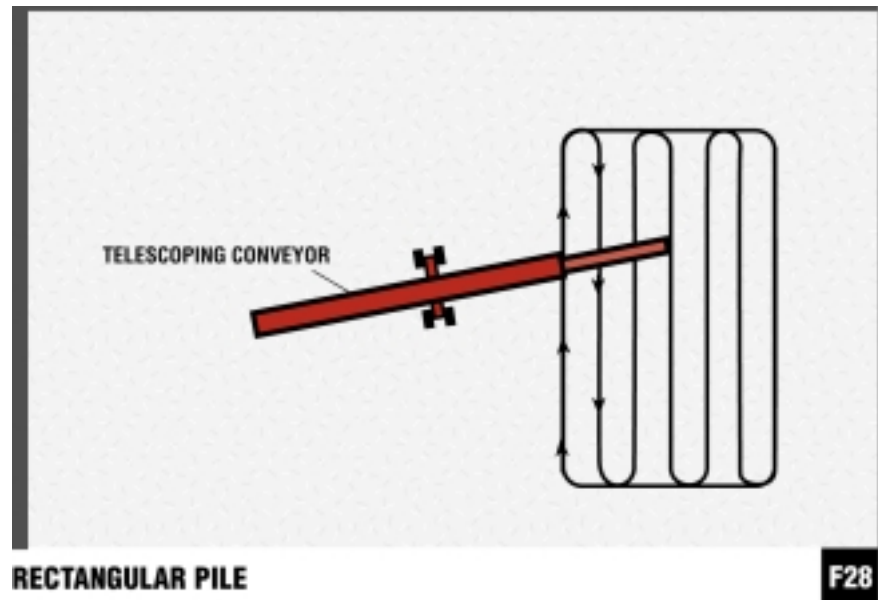
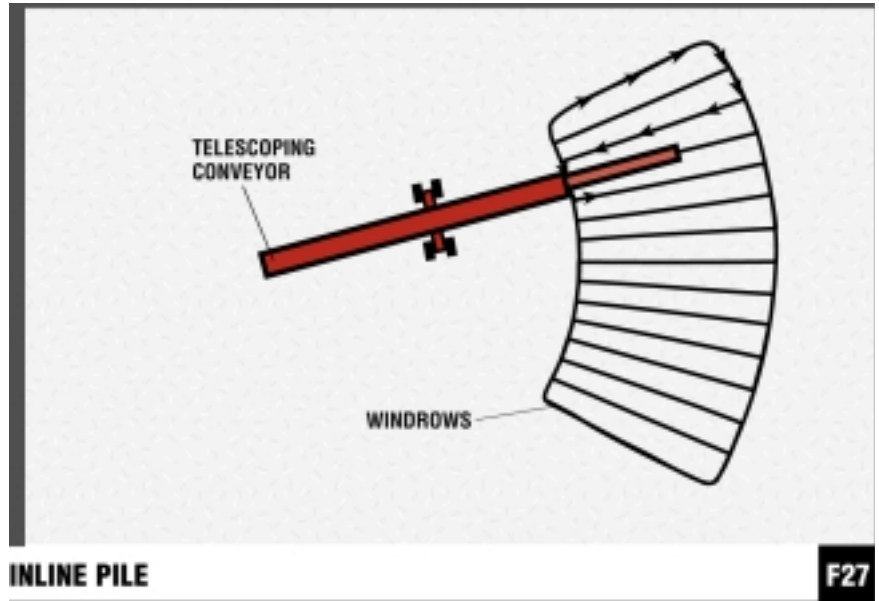
Customized automation extends beyond stockpiling. When loading a rail car or vessel a linear pile is needed. Conventional radial stacking conveyors cannot build the pile. However, a telescoping conveyor with an encoder on the winch can be programmed to build the pile (**Figure 29**). In the past this type of pile would have had to be built by a stationary system with multiple conveyors.

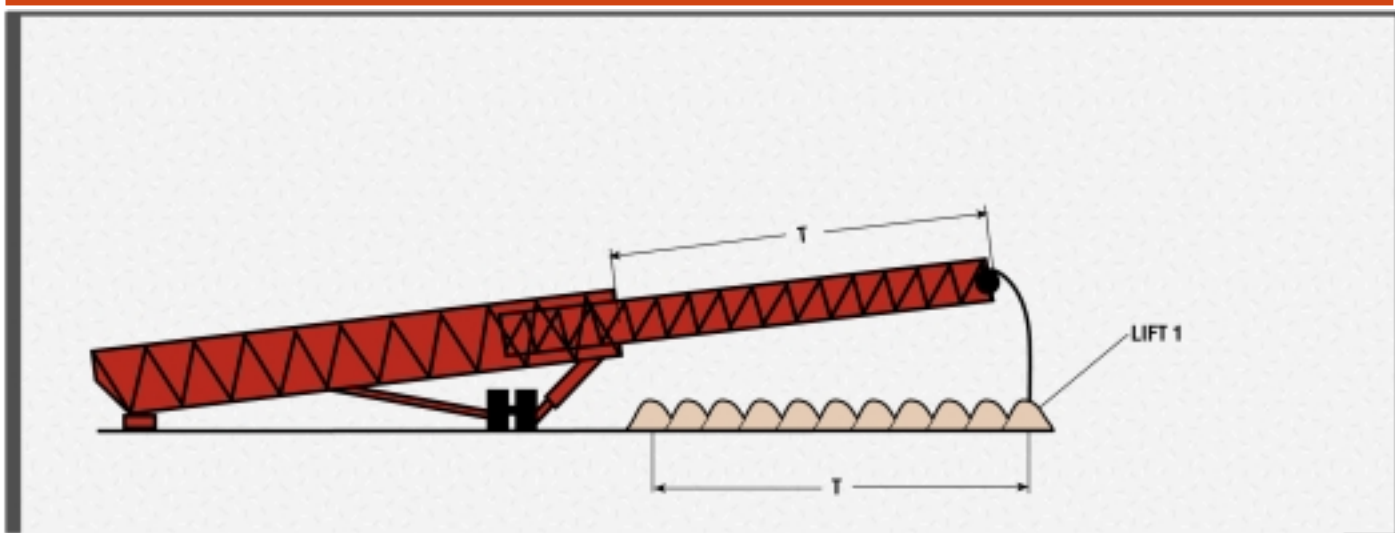
Automation options are not limited to those listed above, as new processes and user expectations will be revealed in time. The automated telescoping conveyor is currently the most versatile tool in stockpiling, and will continue to be the most adept at meeting these new processes and expectations.

PARTIALLY DESEGREGATED PILE

The windrow method of stockpiling greatly reduces segregation, but overrun can still be a problem if the proper method is not used (Figure 5). This occurs when a lift of windrows is as wide as the lift below it. Material in each lift must be prevented from rolling over the edges of the previous lift and creating overrun in order to minimize segregation completely. If overrun is not prevented, certain portions of the stockpile will still be subjected to segregation, and a partially desegregated pile will be created.

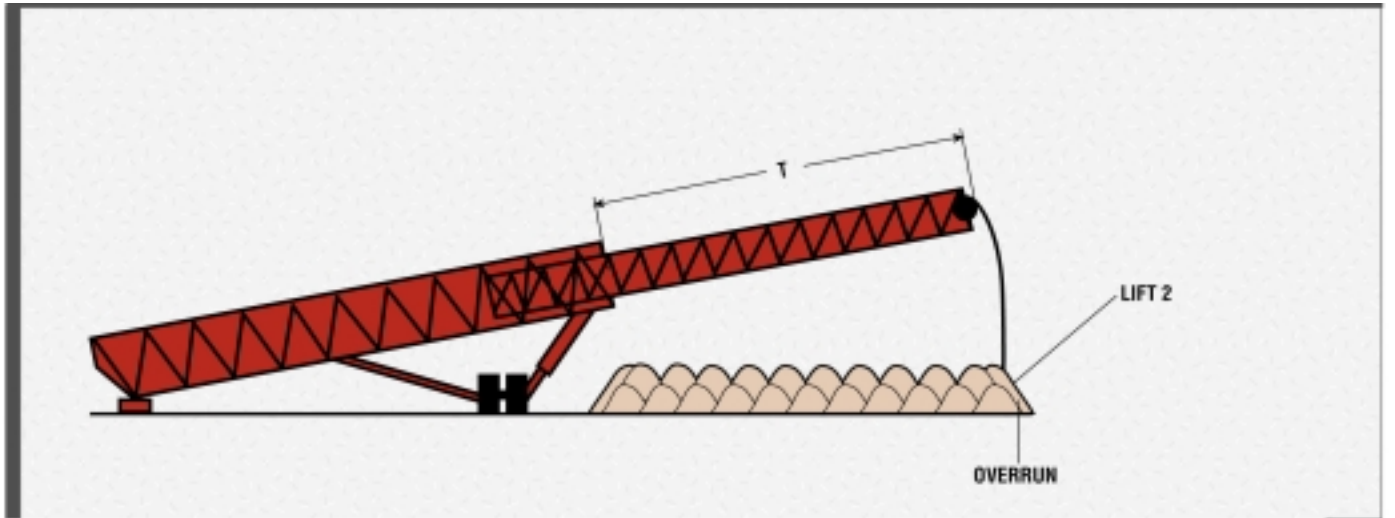
The bottom lift of a windrow pile created with a telescoping conveyor is approximately as wide as the length of the telescoping section of the conveyor (**Figure 30**). When the second lift of windrows is created, overrun begins to occur when the telescoping conveyor reaches its extension limits and is making the innermost and/or outermost windrows. Material spills over the edge of the first lift and rolls down to ground level, creating overrun (**Figure 31**).





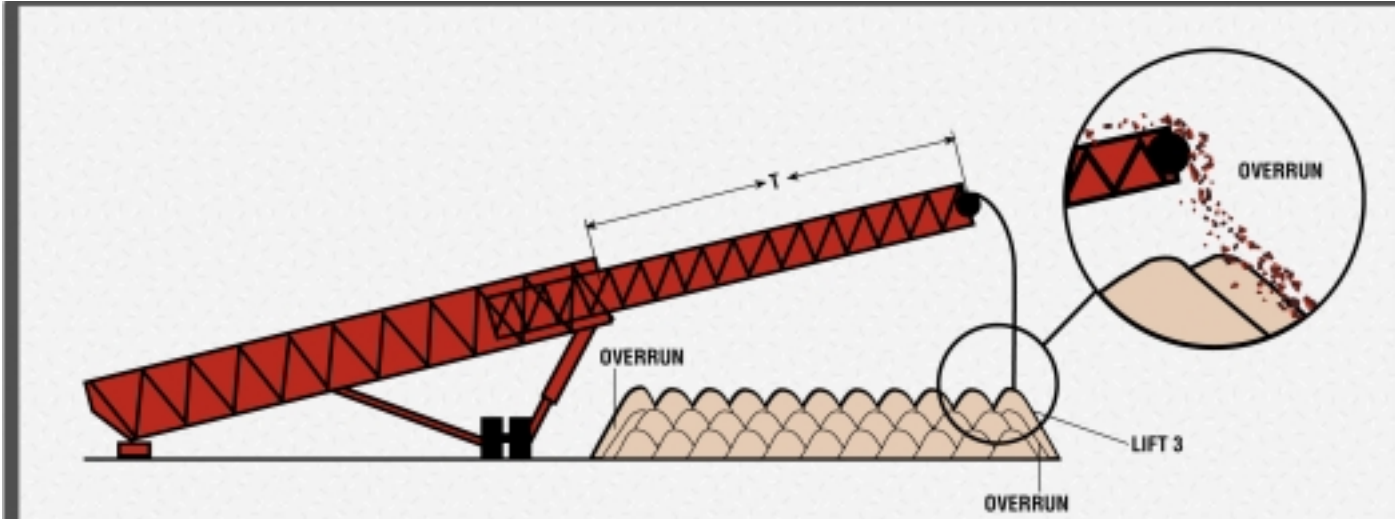
BOTTOM LIFT OF PARTIALLY DESEGREGATED PILE

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SECOND LIFT OF PARTIALLY DESEGREGATED PILE

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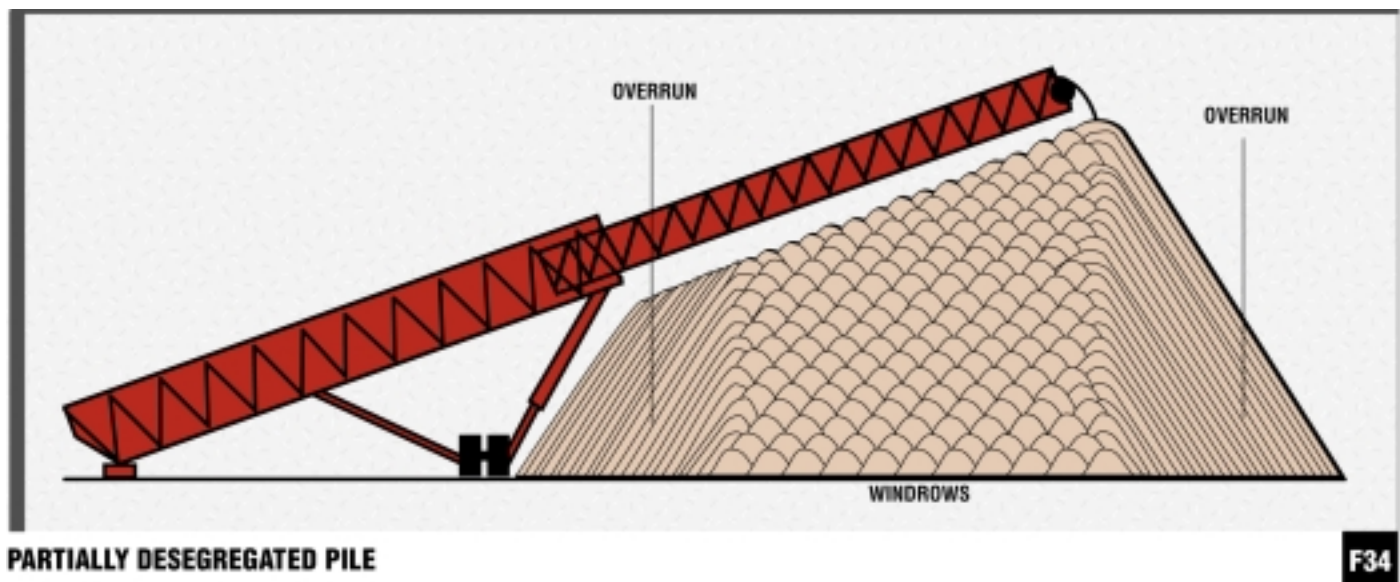
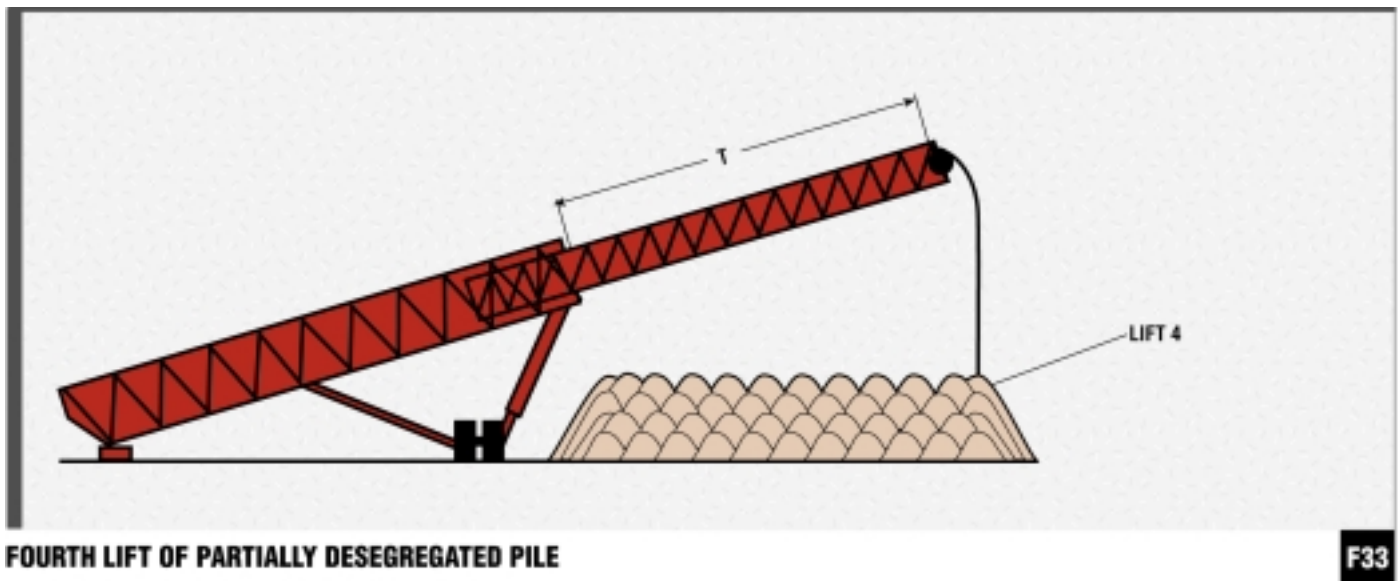


THIRD LIFT OF PARTIALLY DESEGREGATED PILE

F32

The same problem occurs when making the third lift. Again, as the telescoping conveyor reaches its maximum extension, material spills over the edge of the second lift and rolls down the back side of the pile to ground level (**Figure 32**). This problem continues to worsen as the pile gets higher because the slope down the side of the pile gets longer (**Figure 33**).

When a partially desegregated pile is completed, the final result is a stockpile that consists of up to 40% overrun (**Figure 34**). Segregation has been essentially eliminated in the windrowed portion of the pile; but the effects of segregation remain significant in the portion of the pile made up of overrun. In order to minimize overrun, the actual stockpiling process must be altered to create a fully desegregated pile.



FULLY DESEGREGATED PILE

In order to eliminate overrun in a layered windrow pile, the extension limits must be changed for each lift. By changing the limits of travel of the telescoping portion of the conveyor, each lift of windrows can be made slightly smaller than the lift underneath of it (Figure 26).

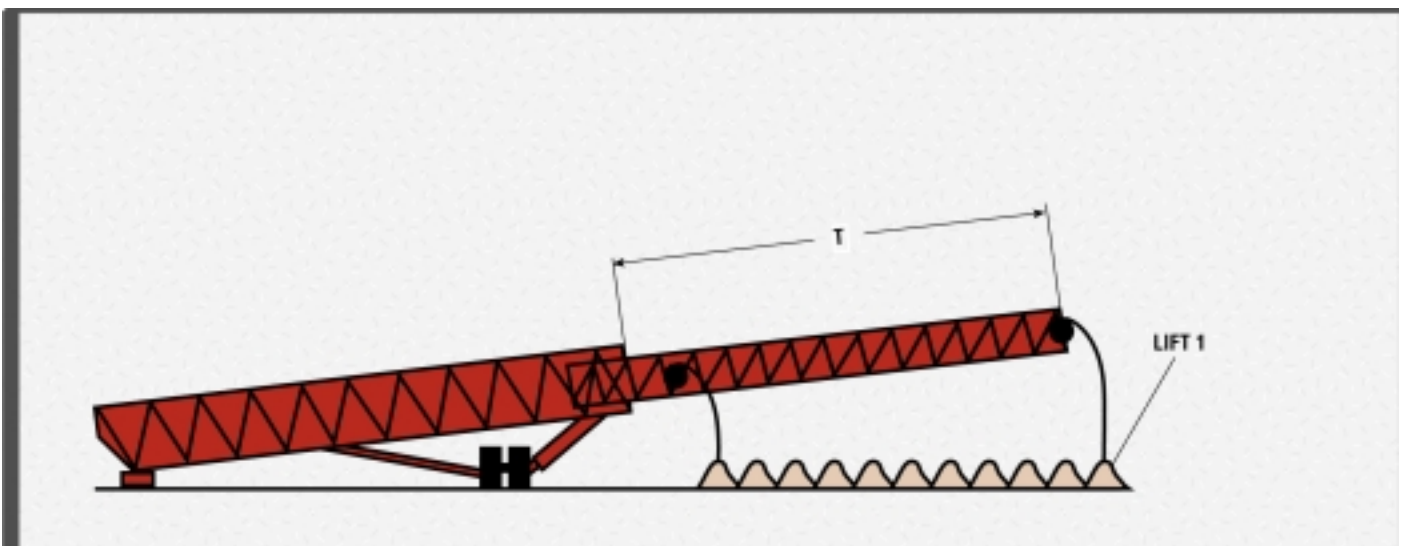
The bottom lift of a fully desegregated pile is created the same way as a partially desegregated pile. The dimensions of the bottom lift are identical. As mentioned before, the base of the pile is approximately as wide as length of the telescoping section of the conveyor (Figure 35).

The stockpiling process begins to differ in the second lift by changing the extension and retraction limits of the telescoping portion of the conveyor (Figure 36). Both of the limits are changed by an amount 'A'. This adjustment prevents material from being discharged from the conveyor over the edge of lift 1. This essentially eliminates overrun.

When creating the third lift of the stockpile, the extension and retraction limits are adjusted again by amount 'A' (Figure 37). These adjustments prevent material from spilling over edge of the second lift and rolling down the front and back of the pile to ground level.

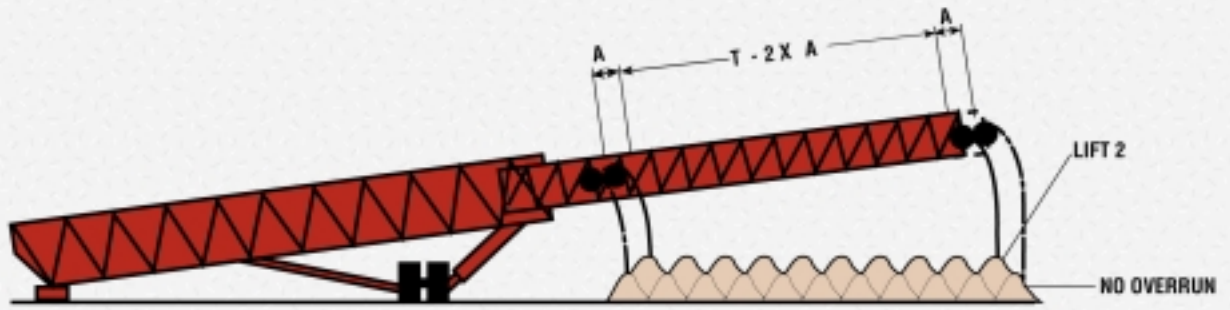
For each subsequent lift, the extension and retraction limits are adjusted to prevent overrun on the front and back of the pile (Figure 38). The limit adjustments actually decrease the distance that the telescoping portion of the conveyor travels. As the number of lifts increases, the telescoping distance decreases. This causes each lift of windrows to be narrower than the lift underneath it.

The cross section of a fully desegregated pile is completely made up of windrows, and overrun is eliminated (Figure 39). Pile volume is sacrificed when creating a fully desegregated; however, the quality of the material in a fully desegregated pile is significantly better than that in a partially desegregated pile, due primarily to the absence of overrun.



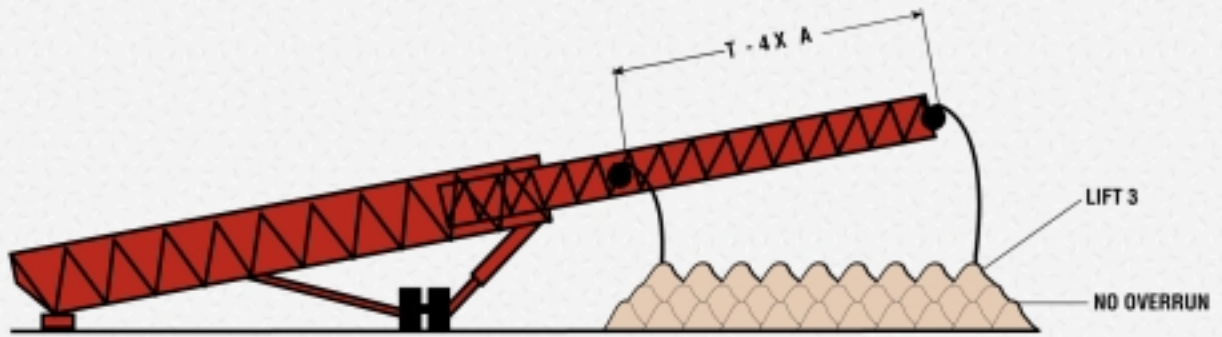
BOTTOM LIFT OF FULLY DESEGREGATED PILE

F35



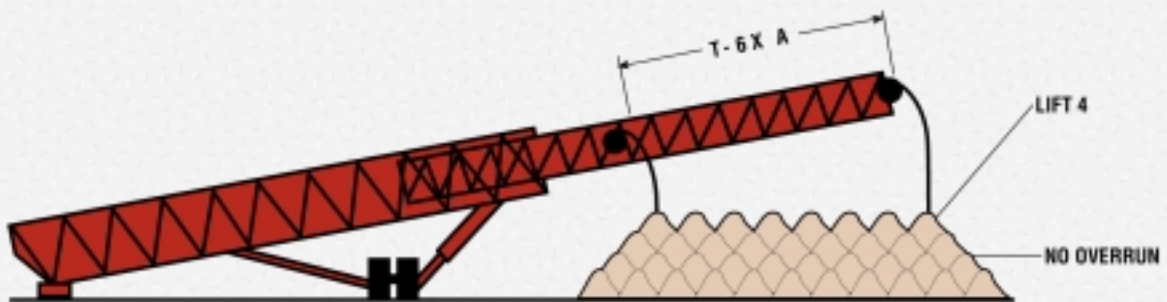
SECOND LIFT OF FULLY DESEGREGATED PILE

F36



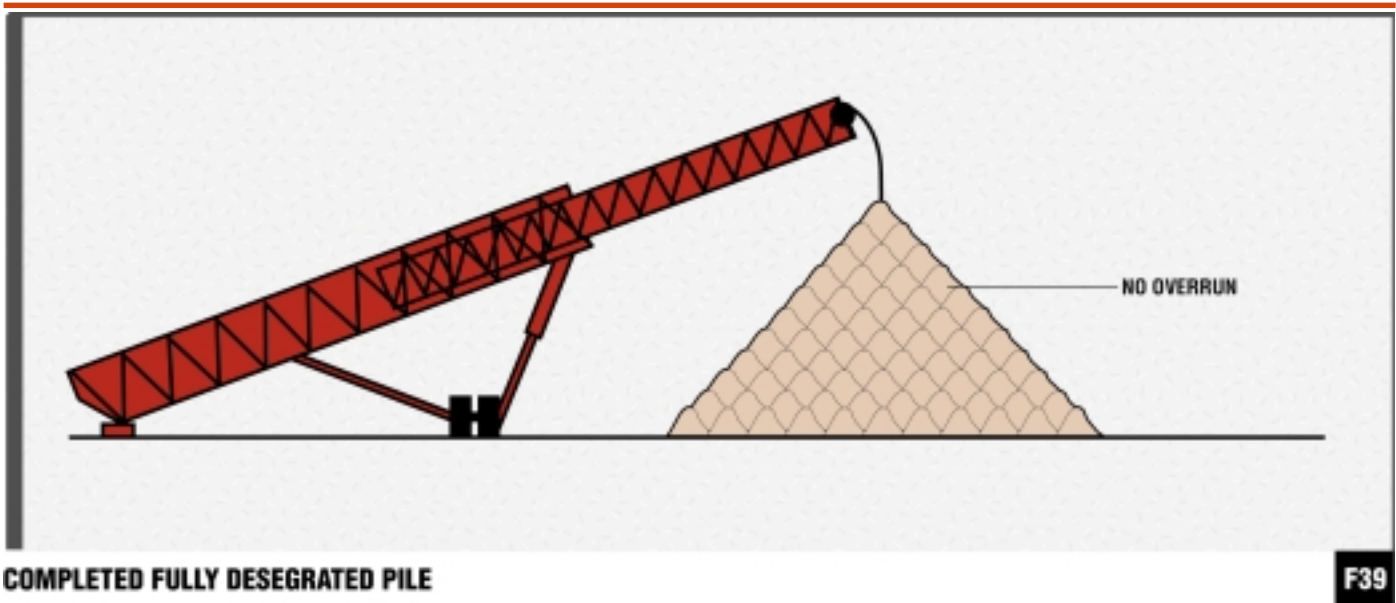
THIRD LIFT OF FULLY DESEGREGATED PILE

F37



FOURTH LIFT OF FULLY DESEGREGATED PILE

F38



Overrun is also created on the ends of a stockpile created by a telescoping radial conveyor. This overrun can be eliminated if adjustments are made to the limits of radial travel of the conveyor. To prevent overrun on the ends of a stockpile, the total radial arc must be decreased inward for each layer.

STOCKPILE VOLUME

The stockpile volumes of a fully desegregated and partially desegregated stockpile differ greatly (**Table 1**). A pile built with a conventional (non-telescoping) radial stacking conveyor is shown for comparison and is designated as area R1. The axle on a telescoping conveyor is placed closer to the feed point than that of a conventional radial stacking conveyor. Because the stinger conveyor is able to retract, the operator is able to stockpile back to the axle. This resulting pile is partially desegregated and is the highest volume pile as indicated by areas R1+R2 (**Figure 40**). The conventional pile has the next highest volume but is segregated and is indicated by area R1. The fully desegregated pile has the lowest volume but is free of overrun and is indicated by area R3 (**Figure 40**). The factor that affects the volume of a fully desegregated pile is the extension distance. By maximizing that extension distance, the fully desegregated pile volume is maximized and the towing length of the conveyor is minimized.

SUCCESS WITH AUTOMATION

Automation is significantly changing many industries as it can offer a means of achieving higher productivity and higher quality products in many different types of operations. Although automation can prove to be the best method of controlling a given operation, there are often several factors that seem to cause some apprehension with automated systems.

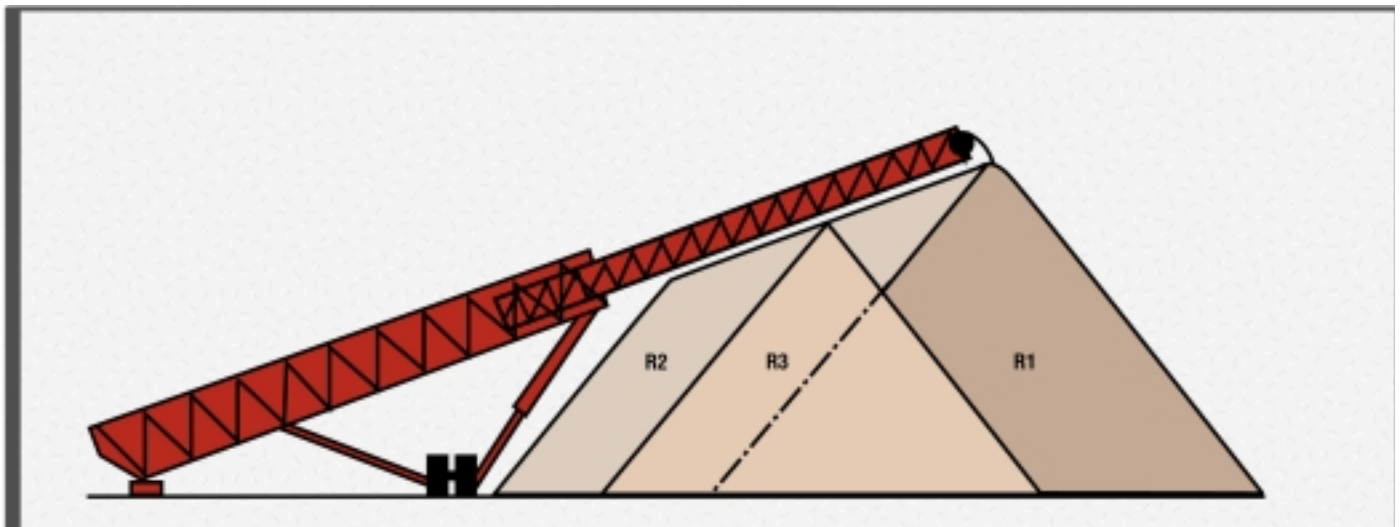
One of the biggest factors is simply the fear of change; especially a change from an existing system that seems to work well to a system that is much more complex. In many cases, the original system may have been a relatively simple piece of equipment, but controls, sensors, and electronic devices are required to incorporate automation. The complexity of an automated system often intimidates a user because of the inability to troubleshoot and fix problems that may arise. It is essential that the manufacturer have a good customer service program to assist users with service and maintenance on their systems. This includes the ability to provide good technical support over the phone and to be capable of responding immediately to the need for parts or a field service technician.

Another concern that users may feel is that they are not capable of learning how to operate an automated system. The key to overcoming these attitudes is for the manufacturer to provide excellent training for the users. It is also important to provide good operator's manuals and reference materials that give clear operation instructions.

			CONVEYOR LENGTH		
			110'	130'	150'
R1	Conventional	Yards	13,400	21,600	32,500
		Tons	18,090	29,160	43,875
R1 & R2	Partially Desegregated	Yards	17,530	27,600	44,050
		Tons	23,666	37,260	59,468
R3	Fully Desegregated	Yards	5,400	8,000	14,000
		Tons	7,290	10,800	18,900

90 DEGREE STOCKPILE VOLUMES

T1



PILE VOLUME COMPARISON DIAGRAM

F40

Finally, automation components often have the perception of being delicate and unable to withstand the harsh environments inherent to many applications. As technology has progressed, suppliers of automation components have considered these factors and addressed the vastly differing needs. For example, there are literally thousands of different sensors available today, and each is designed for a specific application. Ultimately, it is the responsibility of the designers and manufacturers of an automated system to select the right components for the right application. This requires designers and engineers to be well aware of user expectations, application, environment, and what is available in terms of automation components.

CONCLUSION

In conclusion, automation is clearly the way to build a fully desegregated stockpile. An automated telescoping conveyor is the most effective method of minimizing segregation. It will save money and time while providing a better product. The equipment and labor costs of alternative stockpiling methods are higher, and equivalent product quality is unattainable by these other methods. The automation technology available today provides exciting opportunities both now and in the future to maximize the production of high-quality aggregates while reducing or eliminating labor-intensive operations. This will give the producer the ability to make a product that will always meet increasingly stringent specifications.



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