Basic Beet Piler Design and its Application to Construction

READ A. WILKINSON[1]

Part 1—Design Requirements

Due to the expenditure necessary to purchase a modern beet piling machine the question reasonably arises as to what information is essential for the selection of the most economical and satisfactory unit.

If every receiving station were permanent and the acreage constant a special individual design would be necessary for every station in order to maintain a minimum overall receiving cost.

Since this condition very seldom occurs and a fluctuation of acreage per station results, a beet piling unit may be shifted to several different stations during the life of the machine. TJierefore, only a general design may be formulated to determine the standard size unit which will handle the delivery of stations up to a certain peak. Identification of these sizes is by the width of the main elevator belt such as 38-inch, 42-inch or 48-inch.

Desipte the above there are many factors which will determine a final selection of the beet piling unit, many of which will differ depending on the existing climate, soil, growing conditions and receiving methods employed by the individual beet sugar companies.

Although the data herein presented pertain, for the most part, to piler design for southern Idaho much of the information or type of analysis is general.

Most cost analyses are based on tons of beets handled; therefore, consideration of capacity in design economy is of prime importance; consequently, this one factor will be dealt with more at length than any other. It is recognizable that beet storage is also a factor to be considered as are the many mechanical features which promote safety, simplicity in operation, and economical maintenance. However, in reality all have a material relationship to capacity.

In order to determine expected beet delivery it is essential that an analysis of pertinent data from an adequate number of past receiving seasons be made. This will include beet delivery, mechanization, precipitation, and existing beet piler capacities, all of which inter-relationships influence design characteristics.

The overall design of a beet piling unit may be subdivided into five separate catagories as follows:

1. Capacity; 2. Screening requirements; 3. Piling requirements; 4. Operational or mechanical requirements; 5. The economic factors. They will be considerd in this order.

1. Capacity

There are three factors which influence the rate of delivery. First and

[1] Agricultural Engineer, the Amalgamated Sugar Company, Nampa, Idaho.

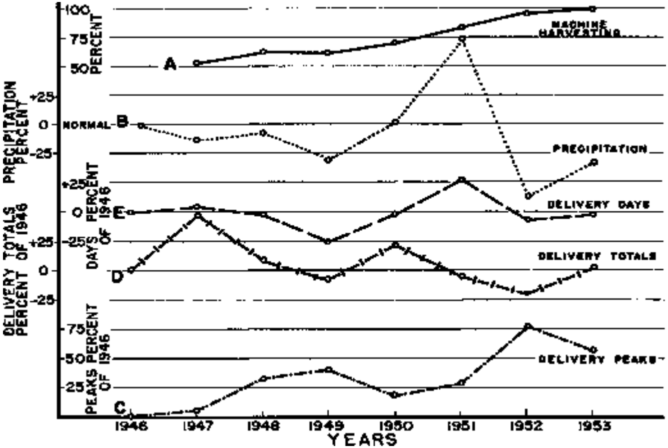

Figure 1

foremost is the use of machines in harvesting the beets, second the weather and third the size of crops harvested.

Graphs have been plotted from compiled data of these three factors for the years 1946 through 1953 in the Nampa-Nyssa districts and the following deductions may be made as shown in Figure 1.

1. An increase to 98 percent in mechanical harvesting is shown on curve A.

2. Curve B portrays the variation in precipitation during the same period wherein it has been below normal for the majority of years.

3. Curves C, D and E are based on the year 1946 from which the following deductions may be made: A gradual increase in delivery peaks have occurred since 1946, which directly follows the increase in mechanization. These peaks are lowered slightly in years of high precipitation and large beet crops, but not sufficiently to eliminate the continual rise.

The fluctuation in total days harvest for each year as shown by Curve E follows quite closely the precipitation shown by Curve B and has gradually decreased.

In Figure 2, delivery by the week was plotted in three characteristic years in which approximately the same tonnage was delivered and the precipitation was about the same. From this information it may be deduced that the time of peak delivery has remained about the same. In fact, out of the eight years investigated only one peak changed radically from the general pattern, and that was the year when the precipitation was the highest above normal. As will be noted from these curves, also the peak tonnage reached has increased each year as has the percent of fall mechanization.

This increase in peak delivery is extremely important with regard to piler design as it is this increase which affects the capacity and selection of the pilers used, since piler peaks automatically follow total peaks where the same equipment is used. While this increase in peaks has been adequately handled in the past due to the 56.5 percent average piler utilization, it will not be possible to continue to handle it in the future as the maximum capacities of the units are rapidly being reached. This is understandable when an analysis is made of past receiving reports which show that average piler peaks have increased 16 percent in the last four years, as compared with weekly delivery peaks, which have increased only 7.4 percent.

For example, in 1953 the piler utilization for the large delivery stations reached a peak of 89.5 percent with the maximum being reached just before noon and again before closing time. If the maximum capacity were

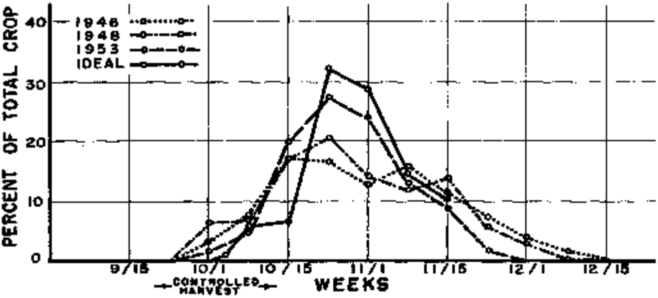

Figure 2.—Weekly deliveries.

maintained during the entire day, the situation would be extremely congested, thus curtailing the growers' harvest operations. Such a condition cannot be allowed, and changes are necessary to alleviate it, either in harvested acres or piler design.

With mechanical harvesting increasing and the growers delivering beets more rapidly, the question arises as to what the ultimate delivery rate will be, or at what point should it be controlled. As seen in Figure 2, the time of delivery has been materially reduced between the years 1946 and 1953, which is inverse to the peak delivery trend. Therefore, it becomes necessary to determine whether it is desirable to increase or decrease the time for delivering beets. The determination of this factor is essential because upon it rests the conclusion as to whether piler capacities should remain as they are or be increased.

Since design, as discussed in this paper, is predicted for the most part

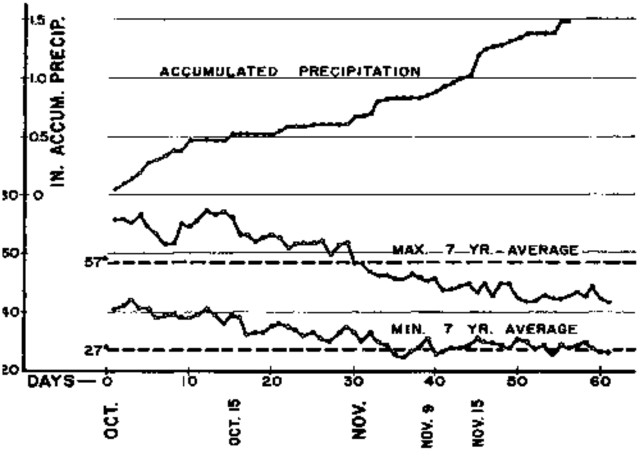

Figure 3.—Temperature and precipitation—7-year average.

on the piling of beets, it is necessary to determine the time period when it is most satisfactory to pile for storage. Factors affecting storage consist of maximum and minimum temperatures and precipitation; therefore, the 7-year average of these for the Nampa-Nyssa district is plotted in Figure 3.

Ideal temperature variation for sugar beet storage in southern Idaho is between 57° and 27° F., when precipitation is low and intermittent. In accordance with these limiting factors, an analysis of the curves indicates that during the fore part of the season the maximum temperatures are the determining factor and in the latter part of the season the minimums are. Since there are only a few available days between these limits, a large latitude must be included.

Because the expected dry and warmer atmospheric conditions are more favorable for harvesting during the piling period than the cold and wet conditions, the shift should be in that direction. Further observation of the curves indicates that the final maximum temperature drop occurs on October 15, thus establishing a date for the beginning of unrestricted harvest and pile storage. The minimum temperatures become unfavorable November 9, which will determine this to be the latest pile date. The precipitation curve indicates that there is a period starting October 10 through November 8 whereby very little precipitation falls; thus, the 26-day period from October 15 up to and including November 9 is satisfactory as far as precipitation is concerned.

Since it is necessary to start harvest two weeks before the beet storage season begins a certain percentage of the beets necessary to operate the factories must be harvested. This will approximate 1 percent per day, leaving the other 87 percent to be harvested in the remaining 26 days. Assuming 1953 as a normal year with 98 percent of the harvesting being done mechanically, it can serve as a base upon which the pro-rated increase can be applied. The delivery for a 26-day period is, therefore, plotted in Figure 2 to show the comparison. From past delivery data we have concluded that peak station delivery for the 48-inch pilers will amount to 1.33 percent of the delivery for the peak week, which amounts to approximately 4,000 tons per day, or a 12 percent increase over the present peak delivery for the present 48-inch pilers. This increase may, of course, be taken care of by longer station hours, but the piler utilization data would indicate that it is an increase in hourly capacity which is necessary to reduce congestion and not more hours. Therefore, we may conclude that the capacity in tons per hour of pilers at peak stations should be increased by the above amount to handle approximately 340 tons per hour.

2. Screening Requirements

The modern piler requires a screen which will operate with greater efficiency to eliminate trash, dirt, rocks and clods. It is necessary that this be accomplished with a minimum amount of small beet loss and interference from mud.

3. Piling Requirements

Storability of beets depends upon many factors, among which are a few features which can be built into a beet piler: namely, the ability to automatically spread the beets and escaping trash uniformly on the pile face. Also, the ability to build piles of different widths and heights without cutting down capacity from beets rolling back on the piling boom belt is important. This is essential in order that piles may be built for either natural or artificial ventilation.

4. Mechanical Requirements

There are many features on pilers which are desirable in that they reduce operational cost, maintenance, and provide convenience and safety.

A piler must be mobile and compact as it is necessary to move these units at times, especially from pile to direct car delivery. This requires a minimum amount of weight per square inch of track area on the ground. Adequate and positive steering is also desirable not only to aid in maneuverability, but to reduce the length of piling areas necessary.

It is also essential that operation and controls of a piling unit be simply arranged for safety, and that consideration be given to minimum labor requirements for both operation and repair. Power and maintenance costs should also receive major consideration.

All possible safety features, with regard to drives and electrical installations, should be incorporated in the unit.

Roomy tare houses and provision for taking tare samples are desirable as are arrangements on some pilers for both side and end dump trucks.

Initial and operational costs per ton of beets handled should be kept as low as possible with regard to all sizes of beet pilers.

Conclusions

1. Design of sugar beet piling machines cannot be confined to a single station, but will, of necessity, be adequate to handle peak capacities for a group of different sized stations.

2. Pilers at present have been resolved into three different sizes with 38-inch, 42-inch, 48-inch width feeder or elevator belts. This, however, could be reduced to two, the 42-inch and 48-inch, provided an option were allowed wherein a piler could be purchased with one or two platforms.

3. The increase in mechanical beet harvesting is one of the main contributing factors necessitating a change in modern beet piler design.

4. Delivery peaks have increased sufficiently due to and along with the increase in fall mechanization to tax the present capacity of many pilers. These peaks are slightly affected by precipitation and size of crop.

5. The date when peak periods of delivery occur has not changed because of the increase in percent of fall mechanization, but a reduction in days of harvest has resulted.

6. Piler peaks follow delivery peaks and, therefore, directly affect piler design capacity.

7. In the Nampa-Nyssa district the ideal piling period in which to receive beets extends from October 15 through November 9, a 26-day period. Peak deliveries for this period, considering an average crop, would increase 12 percent, thus increasing the required peak capacity of a beet piler to approximately 340 tons per hour.

8. Modern beet pilers should have certain mechanical features incorporated *in* their construction to increase the efficiency of screening, and versatility of piling. Also of major consideration are features which reduce operational and maintenance costs, provide safety and simplicity in operation, lend to mobility and compactness.

9. Unit initial and operation costs per ton handled should be kept to a minimum.

Part 2—Meeting Design Requirements

J. G. STONE[2]

The first successful portable sugar beet piler was designed and built by the Ogden Iron Works Company in 1925. During the intervening years many improvements in beet pilers have been made to meet changing harvesting methods. Three principal objectives have been constantly kept in mind, namely:

1. Greater capacities of pilers
2. Better dirt and trash removal
3. Improved condition of beet piles

In addition to the above basic objectives, the mobility of the machines, safety features, reduction of operating crews, lower maintenance, etc., have also been uppermost in the minds of the engineers.

Greater Capacity of Beet Pilers

To achieve increased piling capacity several important factors have been given consideration. Capacity is directly related to the size and number of

[2] Secretary of Ogden Iron Works Company. Ogden, Utah.

loads of beets which can be dumped, elevated, screened and piled, in a given period of time. Several points in the design of a beet piler may be mentioned whilch make for the handling of more and larger loads per hour or per day:

1. Proper platform design; 2. Ample beet hopper capacity; 3. Faster and smoother dumping of loads; 4. Arrangement of dirt conveyor for ease in getting dirt and trash into the grower's truck; 5. Width and speed of feeder and incline conveyor belt; 6. Correct relationship of screen size and speed of screen rolls with respect to tonnages being handled. Other points could be mentioned.

The use of pilers with double platforms has enabled the machines to handle approximately 30 to 35 percent more loads than where single platforms are used. The use of an improved hoisting mechanism has also lessened the dumping time. In recent years our pilers have been equipped with hydraulic hoists which give smoother dumping of the truck bodies and at the same time provide almost foolproof operation.

Longer and deeper beet hoppers facilitate dumping of large loads in less time, thus allowing the truck to get off the platform and under the dirt belt without delay, which permits the following load to be made ready for dumping sooner. The dirt conveyors for delivering the dirt and trash from the dirt hopper to the farmer's truck have also been improved to afford greater speed.

Increased piler capacities have also been obtained by the use of wider feeder and incline conveyor belts, at the right speeds. The screening unit must also be of the proper size, and run at the correct speed in order to handle these greater tonnages. They must also provide the best possible removal of dirt, trash, clods, etc., from the beets.

Another factor tending toward increased piling capacity is the speed and ease with which the piler can be moved when a new segment of the pile is begun.

Better Dirt and Trash Removal

Many types of beet screens have been used over the years. Some have been fairly effective under ideal harvesting conditions and not too effective when conditions have not been ideal. Changing harvesting methods have also required new and better types of beet screens. With the introduction of mechanical harvesting of beets new problems presented themselves which were not noticed when beets were hand topped and hand loaded. The present beet screens have to remove the dirt and trash, as well as rocks, and other foreign matter which are brought in with the beets, consequently the screen is subject to more severe usage. The latest development to overcome these problems has been the use of rubber screen elements. These were introduced to the trade some six years ago. The use of molded rubber screen elements on the screen shafts made it possible for rocks and other foreign objects to pass through the screen without jamming and clogging it. Several other advantages were also noted, among which might be mentioned decreased weight of the screen rolls, smoother operation, less vibration, less bruising of beets, etc.

The screening of beets was further improved by the use of the reverse screen rolls strategically located in the screen unit. By the use of reverse rolls at the proper points in the screen and by providing screens of ample width and area so that the beets could spread out and allow the dirt and trash to come *in* contact with the screen rolls, better and greater dirt and trash separation has been obtained.

While the use of rubber screen elements is very effective in dirt and trash removal, *in* some districts there has been a tendency for the reverse rolls to pull small beets through the screen along with the leaves and trash. This problem seems to have been more pronuouunced in certain areas where mechanical thinning and closer spacing of beets prevail, consequently, with the increase of spring mechanization, a problem has developed which must be solved. To accomplish a reduction of beet loss a proper relationship in speeds between rolls running in the forward direction and the rolls running in the reverse direction was made. Thick-fingered rubber screen elements and a combination of steel and rubber screen kickers were also used on the reverse rolls. All of these have brought about an improvement in the beet screen unit and tended toward a solution of this particular problem.

Another desirable change introduced on pilers during the past two years consists of adding an independent motor for driving the screen unit. This enables the screen to be driven separately from the incline conveyor, thus providing a feature which was not. available with the former driving method. In the single unit pilers of the 1953 model an independent motor drive was used for the auxiliary dirt belt, which made possible the automatic stopping of the auxiliary dirt belt beneath the screen when the main dirt belt was discharging into the grower's truck. Thus, the dirt from a following load would not become intermingled in any way with that of a preceeding load.

Improved Condition of Beet Piles

In the design of beet pilers, much thought was given to features which would improve the condition of beet piles, to avoid losses occasioned by beet spoilage while in storage. In addition to providing the best possible screening and trash removal, other factors such as the proper length of the piling boom, depth of beet pile, distribution of beets across the face of the pile, etc., all have a bearing on how well the beets will keep during the storage period.

The piling boom lengths vary from 50 to 60 feet according to the type of piler furnished. With the 48-inch double unit, double platform pilers the boom can be somewhat shorter than that of the single unit-type pilers. On the 1953 model, single unit machine, with double platforms, a 55-foot boom length was found to be the most desirable. The width of the pile at the base is approximately 134 feet to 140 feet, and the depth of the pile about 22 feet. All piling boom conveyors are motor driven from the head shafts, as it has been found that this location of drive gives the best belt operation.

For many years the piler booms on Ogden Iron Works Company pilers have been motorized for swing, and for the past ten or twelve years, automatic boom swing control has been furnished on all of our pilers. The electrically controlled reversing boom mechanism has time relays so that a predetermined pause at each end of the boom swing is obtained before the mechanism automatically reverses the direction of swing. This pause at the end of the boom swing eliminates the serrations or valleys that previously occurred in the sloping sides of the pile where the boom was immediately reversed without a pause at the end of the swing. Thus, there is less exposed surface on the sides of the pile.

The most important advantage, however, of the automatic boom swing is the even distribution of any escaping dirt or trash across the face of the beet pile. This avoids any concentration of trash and dirt in one place, thus minimizing one of the chief causes of beet spoilage.

Improved Mobility of Piler

An outstanding feature of the Ogden iron Works piler is the ease and speed in moving, when necessary to begin a new segment of the pile. This enables the crew to make shorter and more frequent moves, thus keeping the top of the beet pile smooth and free from valleys. This is important, especially in those piles where the beets remain in storage for extended periods of time before being processed at the factory.

This ease in moving is made possible by the hydraulic steering, as well as hydraulic raising and lowering of the feeder and the platforms.

All of the pilers are mounted on crawler tracks which are driven on both sides of the machine through a differential, thus giving proper traction under all conditions. The width of these tracks and their length is such that the weight of the machine will not impose a greater unit pressure on the ground than is desirable for good mobility. The steering wheels are also of ample tread width so that the unit pressure on them is not excesive.

Safety Features

Safety features in design and construction have ever been uppermost in the minds of the engineers. All motors are provided with magnetic switches, with circuit breaker protection ahead of them. All wiring is of the rubber-covered cord or cable type, and is placed in conduit. The machines are also properly grounded. Safety guards are placed over all drives, chains, gears, etc., to prevent injury to employees and others working or moving in and about these machines. If the machines are to be used for night operation, or during periods of darkness, they are furnished with electric lights adequate for this service.

Future Improvements

Notwithstanding the great strides made in improving beet pilers from their inception in 1925 to the present, each year brings to light new ideas and new needs pertaining to improved design and construction. If greater piling capacity is required, ways will be foand to accomplish this. Ogden Iron Works engineers are open-minded and gladly welcome any suggestions either as to specific improvements, or as to the end result desired. They are willing to cooperate fully in any manner that will foster the design and construction of better pilers.