AGENDA OF THE CEMA ENGINEERING CONFERENCE

BUCKET ELEVATOR COMMITTEE MEETING

Tuesday, June 26, 2012 10:00 – 12:00 PM

A. Call to Order

B. Attendance and Introductions

C. Approval of Agenda

D. Old Business
   1. Bucket Elevator Standards
      a. Review and Approve Table of Contents
      b. Review and Approve draft of section 1 “Bucket Elevator, General Description”
      c. Review and Approve draft of section 2 “Bucket Elevator, Principal Types and Applications”.
      d. Review and Approve draft of section 3 “Material List”

D. New Business
   1. Objectives to be completed by next meeting

E. Next Meeting – June 23, 2013 – La Playa Hotel, Naples, FL

F. Adjourn

Warren Knapp
Bucket Elevator Committee Chair
MINUTES OF THE CEMA ENGINEERING CONFERENCE

BUCKET ELEVATOR SUBCOMMITTEE MEETING

TUESDAY, JUNE 28, 2011

ATTENDEES

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CALL TO ORDER
Meeting called to order at 10:00 AM.

MINUTES APPROVED
Not applicable.

OLD BUSINESS
None

NEW BUSINESS

Election of Chair and Vice Chair –
Warren Knapp will Chair the committee
Jim Rogers will Vice-Chair the committee

Bucket Elevator Standards –
After an introductory Powerpoint presentation by Warren Knapp, we determined (3) topics to focus on first. Warren will work on a “General Description” section for the new standard, while Jim
Rogers and Mark Wilkerson will work on “Principal Types and Applications of Bucket Elevators” and “Material List” respectively. Warren will also send the Powerpoint presentation to Phil to disseminate to the rest of the committee.

**ADJOURN**

Meeting was adjourned at 10:55 AM.
Proposed Table of Contents for Bucket Elevators

Table of Contents

Introduction / History of Bucket Elevators

1. General Description

2. Principal Types and Applications of Bucket Elevators

3. Material List

4. Selection of type based on material

5. Method of Filling and Unloading of Buckets

6. Pulley / Sprocket size related to speed and bucket projection

7. Bucket type and Spacing

8. Bucket Shape related to Material

9. Belt selection

10. Belt Splices and splicing

11. Chain Selection

12. Clearances

13. Calculations and Horsepower

14. Types of take-up and travel

15. Trajectory of material from buckets

16. Safety and safe guards.
History of the Bucket Elevator

Bucket elevators are the most efficient means of elevating free flowing granular materials and most materials even some sticky materials.

Bucket elevators of the centrifugal discharge are normally used and most are of belt type. Friable materials are best handled in continuous bucket elevators that operate at low speeds. The continuous buckets are discharged by gravity on the back of the preceding bucket while passing over the head pulley, thus reducing breakage caused by the centrifugal force discharge of a centrifugal elevator. Bucket elevators usually require the least amount of horsepower for vertical conveying of any conveying system.

The bucket elevator has been in used in the USA for many over a century. In addition, for the most part the same basic design has been followed. Leonardo da Vinci in the 1400’s believed art was the chief instrument of man’s search for knowledge. The ancestors of the modern day bucket elevator first appeared at about 230 BC these devices were predominantly used for elevating water by the use of pots attached to an endless rope. It is believed that the water used for the famous Hanging Gardens of Semiramus was brought up to a height of 300 feet by this means. A remarkable achievement, having regard to the fact, that modern elevators rarely work to heights greater than 150 feet. Since this time, the bucket elevator has gone through a period of evolution. There was a flourish of activity in elevator design and patents between 1850 and 1930. Since that time there has been very little new work or mathematically supported designs developed. As Leonardo da Vinic said “Art is never finished, only abandoned”, this can be said for the design of bucket elevators, development has been abandoned.

There are few in depth texts on bucket elevator design and/or proper application. This is true for all types of bucket elevators. The following are example of early elevator patents

Examples to be added later.
Bucket Elevators

2.1 GENERAL

A bucket elevator consists of a series of uniformly fed buckets mounted on an endless chain or belt which operates over head and foot wheels. The buckets are used to elevate (usually vertically) pulverized, granular, or lumpy materials. The material is received at the boot, raised and then discharged by passing over the head wheel at the top, into a discharge chute. Generally this mechanism is enclosed in a casing, especially the head and foot sections. Some elevators are self-supporting, but more often they are supported by, or at least braced against, a structural steel frame. Bucket elevators will be discussed under the seven headings listed below. Inclined elevators, which were seldom enclosed, were popular for handling crushed stone, but because of OSHA regulations, will probably go out of use (see figure 1.1).

2.1.1 Centrifugal-Discharge Bucket Elevator

In centrifugal-discharge bucket elevators, the material to be elevated is dug out of the boot and discharged by centrifugal force. They are comparatively high-speed elevators, used where the percentage and size of lumps are at a minimum.

2.1.2 Continuous Bucket Elevator

In continuous bucket elevators, buckets closely spaced on chain or belts are designed so that material is loaded directly into the buckets, usually through a loading leg, instead of being scooped up in the boot. Discharge over the head wheel is accomplished by transfer of material from the discharging bucket to the front of the preceding one, which acts as a moving chute to the fixed discharge chute. Sometimes styled Super Capacity, large-capacity continuous-bucket elevators are made with specially designed steel buckets attached at their sides to double-strand long-pitch steel chain.

2.1.3 Positive-Discharge Bucket Elevator

The positive-discharge bucket elevator should be considered where materials tend to stick in the buckets or where fluffy materials are handled. With its buckets at intervals on double-strand chain, this elevator picks up its load in the boot (as does the centrifugal-discharge type), but because of its lower speed, does not depend upon centrifugal force to discharge material from the buckets. The buckets are completely inverted by snubbing the chains after they have passed over the head wheels, giving them opportunity for complete discharge at relatively slow speed and horizontally as a scraper flight conveyor. Steel buckets, rigidly attached to double-strand steel bar-link, long-pitch roller chain, travel along a continuous steel trough on the horizontal loading run, picking up the material en route. At the lower comer upturn, a special steel comer trough is used to fill the buckets before starting their vertical run. At the upper comer, another curved comer piece is provided to transfer the load to the upper horizontal run, from where the "material can be discharged at intervals through openings provided with slide gates. The discharge of the bucket is steep enough to empty as it passes over the discharge opening. It is seldom used, because it is slow and expensive.
2.1.4 Internal-Discharge Elevator

The internal-discharge elevator works well in continuously gently handling small bulk articles such as bolts or small castings. Buckets are loaded internally in casing from a chute extending through one side of the casing. Because of their infrequent use, no further space is devoted to them.

2.1.5 Bucket Elevator on Incline

A bucket elevator can operate on an incline, if the chain is guided. If the angle of inclination is over 45° from the vertical, it is better to use an apron or pan conveyor.

2.1.6 Centrifugal vs Continuous-Bucket Elevators

Normally a centrifugal-discharge bucket elevator can handle lumps up to 1 in. if they are not more than 10% of the required capacity. When the lumps are more than 10%, the continuous buckets should be used. Because of its lower speed and methods of loading, the continuous-bucket elevator will cause less breakage of fragile materials.

Belts should be used for corrosive material. If chain is used, it should be heat treated, and Everdur bronze pins and stainless-steel S-shaped cotter pins should be specified. Some material may require alloy buckets. If the material is damp or wet, even if the capacity is small, a double-strand super-capacity continuous-bucket elevator, equipped with flat bottom buckets, or a positive-discharge bucket elevator should be used. If there are fines present, there is the possibility of the fines sticking to the bottom.

2.1.7 Preliminary Selection of Type

Table 2.1 tabulates the properties of the various types of elevators.

2.2 CASING

The elevator is usually enclosed in a steel casing, to provide a means of support and as a matter of safety and dust retention. A casing can be made dust-tight, either by using a sealing medium, or continuously welding the corner angles to the plate. Figure 2.2 shows details of dusttight construction. These casings are regularly made with inspection cleanout doors. For free-standing elevators, structural considerations, such as strength of the sections and the size and number of anchor bolts to resist wind, often will dictate the narrow dimension of the casing and its composition.

Steel plates with corner angles provide a substantial support to the complete unit. Elevators are usually self-supporting and free standing up to 30 ft, with some even up to, say, 60 ft above the boot with special design. Above these heights, the casing is self-supporting but not free standing, and must be braced against the building or silo for heights over 30 ft.

In some cases, the head shaft supporting the complete chain and buckets is mounted on building steel, to take the load off the casing, which then acts simply as a cover, carrying only its own weight. Very large drives (motor and speed reducer) should be supported directly on the building steel or tower, rather than on the elevator casing.

2.2.1 Drives

A V-belt drive from the motor to speed reducer is recommended. Action is similar to that of a shear pin: the belt comes off the sheaves should anything become jammed.
Intermediate sections of elevators are usually made of 12, 10 or 7 gauge steel, in sections 8-10 ft long. These should be designed using cold formed thin shell analysis. The casing acts as a column, and can support a very heavy vertical load. For easy inspection inside the casing, large inspection doors are usually placed in the intermediate section above the boot, or about 3 ft above the floor in a section that passes through a floor. Special consideration of casings with inspection or service doors to ensure the structural integrity is maintained.

The head sections of elevators usually are designed with the hood or top cover split, so the two parts can be easily removed for inspection. A hinged door can also be located on top of the cover, or on the inclined portion forming part of the chute, both for inspection and when necessary for watching the discharge of material or servicing the throat plate.

For servicing the elevator, a casing should be at least 6 in. wider than the bucket. For tall elevators, say over 75 ft, a bigger allowance should be made to prevent the buckets from slamming against the sides of the casing.

For handling explosive materials, refer to later chapter.

2.2.2 Inspection Doors

An example of a dust tight inspection door is shown on figure 2.3. When handling fine and dusty material, it is a necessity. This can be placed anywhere in the elevator casing, particularly in the head and boot sections. Most manufacturers have their own design, and should be allowed to use it for economy.

2.3 ELEVATOR PITS

Elevators generally are placed in pits, although this should be avoided wherever possible. If pits must be used, ample space should be provided in both length and width to allow for maintenance. A good rule is to provide a minimum clearance of 24 in. on one side and boot shaft length plus 24 in. on the other side of the elevator. The feed inlet point of the continuous-type elevator is somewhat higher than that of the centrifugal elevator, necessitating a deeper pit when located below ground level.

2.4 BOOT SECTION

Steel elevator boot sections should be made of not less than 10 ga steel for elevators under 30 ft (those with very low capacity) and 0.25 in. for elevators above 30 ft. In elevators the boot section supports either part or all of the entire unit.

Removable doors and side plates can be installed in boot sections, to make it easier to clean out the boot by hand, when and if required. In industries where products cannot be mixed or contaminated, the boots have to be cleaned out after each operation or run. In some cases, the entire sides of the casing are made removable for cleaning.

Normally, the location of the point of bottom of the inlet in a boot occurs at the center line of the boot pulley in its upper most position or between 4 in. and 6 in above this point for centrifugal types, Two bucket spaces generally about 20-26 in. for continuous types, above the centerline of the boot or shaft in its highest position.

An allowance of at least 6 in. below the buckets, with the takeup in the lowest position, should be made for cleaning-out purposes.

2.5 HEAD SECTION

Figure 2.5 shows an elevator head section with head takeup and one method of supporting the drive mechanism. This is a self-supporting casing. Normally, the point of discharge is located as shown on the figure; that is, 6 in. below centerline of the head shaft, projected on a 45° line downward. An adjustable throat plate in the bottom of the discharge spout is usually used to prevent materials from falling down the casing to the boot.

When handling very fine and dry materials, the 6 in. vertical dimension should be made 12 in. This provides more time for the buckets to discharge the fine material. In some cases, the head shaft supporting the chain and buckets is mounted on building steel. The casing then acts as only a cover, with no machinery load on it.
The head sections of elevators are made with either fixed shaft or takeup shaft. Covers should be made split where possible so that the two parts can be easily removed for inspection and maintenance. A door opening can be located on top of the cover or the inclined part of the discharge spout, both for inspection and for checking the discharge of material (see figure 2.6). For dust takeoff, one connection can be made in the boot section just above the loading hopper, and one at the discharge chute or at the top of the elevator. Provide pipe connection at the top of each. In handling dusty material, a good head shaft dust seal should be used to prevent the dust from coming out of the head section of the elevator casing.

2.6 PLATFORMS AND LADDERS

On vertical elevators of any height where the head shaft cannot be easily reached by maintenance personnel, it is necessary to include a standard steel ladder attachment to the casing, including a steel safety guard beginning 7 ft from lower floor level, and extending to a steel platform. This platform should be of ample size for working on, with the floor of expanded metal, grating, or diamond floor plates. In areas where considerable snow falls and the elevator is located outdoors, an open grating should be used to rid the platform of ice and snow and to prevent slipping. Intermediate platforms should be provided every 30 ft or so.

Handrails should be of standard design, made of angles or piping as approved by safety regulations. Steel toe plates about 6-in. high must be included to prevent a person's feet from moving off the platform. A hoist beam can be provided about four feet above the top of the elevator casing on line of the head shaft, to assist in maintenance work. A V-belt drive from motor to speed reducer is preferred by some because the belt will come off the sheaves should anything become jammed.

2.7 BUCKETS

Malleable iron buckets, either continuous type or type AA, have a Brinell hardness of about 120. Promal buckets are heat-treated, malleable-iron buckets with a Brinell hardness of 190. Buckets should be at least four times the size of the lumps, to get required capacity and avoid spill. For a width of bucket greater than 16 in., two strands of chain (or a belt) must be used. Charcoal, especially, requires wide buckets on two strands of chain. All steel buckets today are made of welded construction, either spot welded or continuously welded, depending on the fineness of material handled. For abrasive material, heat-treated, malleable-iron or cast buckets should be used.

High-density polyethylene bucket that is used primarily in the handling of grain, feed, cottonseed oil, salt production, soybean oil processing, and similar products. These buckets are rustproof, shatterproof, sparkproof, and self-cleaning. They weigh a third the weight of steel buckets and a fifth of malleable iron. There also are Low-Profile (LP), designed to increase the overall capacity by closing up the spacing on the belt. Care must be given to the selection and use of a LP bucket, it is best to use one that has been specifically design for this application and not just a truncated standard.

In light fluffy material, four or five holes, about 1/4 in. in diameter in the bottom and 1/4 in. diameter in the sides near the bottom, are placed to break the suction or vacuum created by the speed of the bucket in picking up the load in the boot. In polyethylene or other similar material buckets these hole need to be larger in diameter. Without these holes, the light materials usually stay in the bucket and go down to the boot again, often piling up and causing an undue strain for the buckets to pick up and, incidentally, increasing the horsepower required. Very little if any capacity is lost through the holes. In handling hot cement or gypsum, at 200-300°F, the holes in the bottom of the bucket help cool the material. The holes can be used for material at higher temperatures, and the cooling can be augmented by introducing outside air into the casing.

Alternating buckets are used on wide belts to obtain a better pickup in the boot of the elevator, and to prevent any possible flooding of the boot with an avalanche of material coming to it. With a single bucket extending across a wide belt and spaced apart at varying intervals, a slight void space could result as the buckets are turning around the foot pulley. With a continuous feed, the material would tend to pile up and finally stall the elevator (see figure 2.9). Buckets are discussed further under each type of elevator.
2.8 CHAIN

Malleable chains are made with a Brinell hardness of about 120. If necessary, the chain can be made more tough by processing the malleable iron. When handling abrasive materials such as sand, gravel, stone, or alloys, toughened malleable iron should be used (refer to paragraph 3.8.3).

Different chain manufactures have hardened chain each has different names and processes to create this chain in general they all are about a Brinell 190 and have a gain of about 25% in ultimate strength. It is almost impossible to get a Brinell hardness much above 190 by heat treatment.

For high elevators, say, 75 ft or over, it is also advisable to use two strands of chain. In that case, the specifications should require the strands to be matched and tagged right- or left-hand, although they are not actually right- or left-hand design. The two strands of chain are rigidly attached to the bucket and no two chains stretch alike during operation. To meet this specification, the manufacturer will shop-assemble these strands of chain, to make sure that the attachments are opposite each other and to tag each strand properly. If the erection is properly done, the buckets will be straight, even if the attachments are slightly off.

On double-strand chains, some preference has been expressed for the use of 6-in. pitch instead of the standard 12-in. pitch, with the bucket attachments every other pitch. This is done to run the chain more smoothly going over the head sprockets. While it is true that by shortening the pitch, the chain will follow more closely to the circumference of the sprocket, it is doubtful that the extra expense can be justified. Where the pitch is 18 in., a 9-in. pitch may be justified.

The selection of the type of chain, that is, malleable or steel combination, is dependent on the type of material to be handled, capacity required, type of duty (continuous or intermittent), and height of elevator. Class C combination chains are economical for general elevator service. SBS bushed chains are widely used for heavy duty and high elevators or those handling abrasive materials.

A variety of chain is available and shown in manufacturers' catalogs. Those most commonly used are shown in tables 3.2 and 3.3. Basically, however, the SBS-110 and SBS-102B are easy to obtain and have proved themselves satisfactory in most installations. SBS and C combination chains are used in elevators. For handling gritty and abrasive materials and in high vertical elevators, SBS chain is preferred. Class C combination chain is less expensive, and is used on high vertical elevators handling aggregates, cement, and similar products. For other chains refer to table 2.3.

2.8.1 ServiceFactor

Here are summarized service factors for only those items that are normally involved in elevator and conveyor work:

- Uniformly loaded: 1.0
- Not uniformly loaded: 1.3
- Reciprocating conveyors: 1.5

Multiple Strand Factor
- 2 strands: 1.7

2.8.2 Recommended Speeds

The recommended speeds for various types of elevators are shown in table 2.1. For the maximum speeds of all conveyor and elevator chains based on the number of teeth in the driving sprocket, refer to tables 1.5 and 1.6.

2.8.3 Chain versus Belt

Choosing between chain and belt as an elevating medium depends upon the characteristics of material handled. Where the temperature of the belt is likely to exceed about 250°F, it is safer to use chain, and select the best quality obtainable for the
service. Hot materials up to 450°F (232°C) can be handled in continuous buckets mounted on standard chain. If the temperature goes to 600°F (315°C), special steel buckets mounted on hardened malleable chain should be used. Most malleable or steel chains will stand up to 600°F (315°C). Above 600°F, heat-treated alloy chain must be used. There are high-temperature belts on the market which may be used under certain conditions. It is advisable to consult with the belt manufacturer.

A number of manufactures offer a Wing-Type Pulley. These pulleys are installed on the boot or foot shaft and are usually self-cleaning, offering maximum protection from belt damage as a result of lumps or foreign material under belt. In this case, it is usually better to use chain. Whatever type of equipment is used, due consideration should be given to the lift factor. The lowest initial cost frequently becomes the more expensive in the long run. Most materials with lumps up to 2 1/2 in. can be handled with chain.

Abrasive materials, such as sand and abrasive grain, should be handled by belt instead of chain because the fine particle size could easily get into the chain joints and cause rapid wear. If any of this class of material should be damp or wet, the belt may slip on the head pulley unless lagged with a herringbone-cut-groove rubber cover. Belts should also be used for corrosive material. If chain is used, it should be heat-treated. Corrosive materials may require alloy buckets, and Everdur bronze pins and stainless steel S-shaped cotter pins should be specified.

Usually when belts are used, on a continuous elevator, especially outdoors, the pulley must be lagged, or covered with a rubber covering vulcanized, slide or rough-top or with herringbone grooves cut into it, to get good contact with the belt.

When selecting a belt as an elevating medium, materials that pack and tend to build up between the belt and pulley, as well as rough or jagged particles that damage the belt by becoming lodged between buckets and belt, should be avoided. To some extent, these difficulties are alleviated through the use of spacers between the bucket and belt and wing pulleys on the foot or boot shaft. In handling lumps with sharp edges, it is usually better to use chains. These lumps may become lodged between buckets and belt, resulting in damage to the belt as the material is picked up in the boot, or as the belt passes over the head pulley.

2.9 TRACTION WHEELS AND SPROCKETS

For general-purpose installations where there are no frequent shock loads, the arm or spoke-type sprocket is used. Plate-center sprockets (arm sprockets filled in to make a solid center) are used where shock loads are anticipated or where the maximum allowable chain pull on heavy-duty chains is required. Split sprockets can be furnished in arm or plate-center sprockets to facilitate mounting or removing them from the shaft without disturbing the bearings or the shaft itself.

Hunting-tooth sprockets have an odd number of teeth, with the pitch of the teeth one-half that of the chain. Because of the odd number of teeth, the chain barrels contact the intermediate teeth after each revolution of the sprocket. Therefore, each tooth has one-half the number of contacts that it would have on a regular full pitch sprocket over any period of time, thus increasing the life of the wheel on high-speed shafts.

Traction wheels (without teeth) and sprocket wheels also are made with cast-iron solid-hub centers, and with sectional bolted rims that can be removed without disturbing the hubs in any way, and replaced quickly with a minimum of down time. There is a growing tendency to use traction wheels at the bottom instead of sprockets. Traction wheels cannot be used at the foot, as the chain will slip off. There is always traction at the head because of the load. When the elevator clogs, the traction wheel will slip. It should be used for elevators 50 ft and over, and sometimes over 35 ft when handling abrasive materials. Some prefer to use the same sprockets at foot and head so that, in an emergency, the foot sprocket can be used at the head, if the teeth are not too badly worn. Some manufacturers of sprockets have developed a method of casting chrome-nickel inserts into the rim of the sprocket to provide great strength, toughness, and abrasion-resisting qualities. Split (two-piece) sprockets, bolted together at the rims and at the hubs, also help to reduce labor costs.

2.10 TAKEUPS

Normally, elevators have the screw-type takeup on the foot or boot shaft unless space does not permit. If it is necessary to place the screw-type takeup on head shaft, the centers of the bucket elevator should not exceed 90 ft, because the total weight of chain (or belt) plus buckets and load in buckets on up or carry side, is hanging on the takeup screw in tension (see figure 2.11). Wherever a head takeup is used, the next larger sized head shaft from that recommended should be used, as the vibration is transferred to the head shaft through the pickup in the
Gravity takeups are used on many elevators, particularly on powdery or aerated material such as cement, lime, and gypsum. A softening effect is encountered at the pickup which must be absorbed by this floating take-up. The frame supporting the shaft and wheel simply rides up and down in angle or channel guides, attached to the inside of the casing. Usually there is enough weight in the complete takeup to keep it in position but, if necessary, additional weight can be placed on the movable steel or cast steel frame (see figures 2.12 and 2.13). The sprocket, or traction wheel, runs loose on the shaft and is kept in place by safety collars on each side of the hub. The diameter of the hub is much larger than necessary, so that in the event the bore of the wheel becomes sloppy, instead of discarding the wheel, it can be bushed. No lubrication is provided since the shaft is pinned and does not rotate. Figure 3.14 shows a head shaft equipped with a differential band brake (back-stop) that is used to prevent the up, or carrying, side from running backward in the event of a power interruption. The backward drift is expected to be less than 2 ft and, upon resumption of power, the brake is immediately released. External back stops are preferred on large horse power units over ones internal to the reducer.

2.11 HORSEPOWER

There are several formulas in use for computing horsepower. In general, they are based on two principles:
1. The weight of the material in the loaded buckets. The weight of the chain or belt and the weight of the buckets on the up-run is balanced by the weight of the chain or belt and the buckets on the down-run.

2. An allowance is made for the extra load at the boot, and for boot pulley friction. From tests, the value has been assumed to be the equivalent of 250-500 lb of load. Thus, for continuous buckets, it will be \( \frac{10 \times 12 \times w_m}{s} \) and \( \frac{30 \times 12 \times w_m}{s} \) for centrifugal discharge (spaced) bucket elevators.

2.12 STANDARD DESIGNS

Standard designs of elevators are given in tables 2.4, 2.5, and 2.6. It is not advisable to use the tables for final design. The weight of the buckets and their capacity are always subject to change, because of the abrasiveness of the material, the weight of the material, the size and percentage of lumps, the fluidity of the material, the rate of delivery of the material to the elevator, the moisture content of the material, and the speed of the buckets.

2.13 BELTS

The widths of the belts for various size buckets is given in table 2.5. It is good practice to use no fewer than four plies, even for the lightest loads. For preliminary design purposes, assume the weight of the belt and attachments to be 6.5 lb / ft of belt width.

2.14 CENTRIFUGAL-DISCHARGE BUCKET ELEVATORS

(Vertically Spaced)

2.14.1 General

A centrifugal-discharge elevator is designed to operate at a high speed, usually from 185 ft to 300 ft or more per minute, picking up material in the boot, as it is fed to it, and discharging the material by centrifugal force out of the buckets, as they pass over the head sprocket or pulley into a chute attached to the elevator casing. For very fine materials, similar to gypsum and cement ( - 10 mesh to 200 mesh), experience has shown that the speed can be reduced to about 185 fpm. The head wheel diameter will vary between 20 in. and 31 in. Speed is critical. Travelling slower than recommended may not allow material to be discharged by centrifugal force, and material may come back on the return run. Travelling faster than recommended may cause material to hit the hood and bounce back down the return run.

The size of the head wheel \( (D, \text{ in ft}) \) and the rpm of the head shaft may vary, but the speed of the elevator \( (\text{fpm} = D \times \text{rpm}) \)
rpm) must be maintained in order to avoid backlegging (return of material on the down run), regardless of the required capacity. For grain, cottonseed, wood chips, and other lightweight materials, however, the double-leg casing elevator, having buckets mounted on a belt and travelling at higher speeds, is frequently used. Bucket speeds for such units range between 350 fpm and 750 fpm, the head wheel diameter ranges from 24 in. to 84 in., and the spacing of the buckets will vary from bucket projection plus 2 in. to 24 in. The capacity will vary between 14 tph and 1500 tph for material weighing 50 PCF. This type of elevator usually is enclosed in a steel casing to provide a means of support, and as a matter of safety and dust retention.

On a centrifugal-discharge chain elevator, inclined about 30° from the vertical, the single strand of chain can be supported on the up, or carrying side, on single flanged rollers spaced 6-8 ft on centers. The return run can sag if there is plenty of clearance; if not, the return run can be supported by having the buckets slide on two angles, forming a track, to keep the return run in the proper path (see figure 2.15).

A centrifugal-discharge elevator will handle almost any kind of fine or small lump materials. It operates well when handling dry and free-flowing products such as grain, coal, petroleum coke, sand, sugar, salt, chemicals, limestone dust, gypsum, sulfur, and cement. The size of the lumps should be 2 in. and under, with the greater part of the volume under 1 in. If there are many 2-in. lumps, the buckets should be at least 12-in. wide, regardless of capacity. This type of elevator should not be used for materials containing over 10% to, say, 15% of lumps, because of the possibility of plugging in the boot, and the difficulty in retaining lumps in the buckets as they travel upward. It should not be used where breakage of material is to be avoided. Continuous-bucket elevators should be used instead.

2.14.2 Buckets

The size of the buckets ranges from 6 in. x 4 in. (6-in. long with 4-in. projection) to 24 in. x 15 in. The spacing of A or AA buckets can be between 13 in. and 24 in., depending on capacity. The A buckets are similar to AA, but are built lighter and of smaller capacity. They are seldom used. The buckets may be malleable or cast iron, steel, or plastic. The buckets are normally attached to a single strand of chain or belt with what are known as K attachments, spaced at intervals. The K-1 attachment has 2 holes, and the K-2 attachment has four holes. The manufacturers' catalogs give the type of attachment to be used for fastening to the back of the bucket, and the punching required for the belt. It depends on the minimum and maximum size of the bucket (refer to table 2.7). Since the plastic buckets are not adapted for hard digging in the elevator boots, it is advisable to place one style AA bucket (malleable iron, reinforced digging edge) on every sixth to eighth attachment. This bucket will clean a path through the caked material in the boot of the elevator housing, so that the plastic buckets do not have to dig, only elevate. This malleable iron bucket Should be inspected at regular intervals for wear and corrosion.

2.14.3 Inclined Elevators

A centrifugal-discharge elevator, equipped with either chain or belt, can operate on an incline at the same speeds as vertical elevators by welding or attaching steel flats on back of buckets, to ride on steel angle track attached to elevator casing sides, for both carrying and return runs. The use of this steel angle track on return run prevents sagging of chain and bucket line, saving much space. A belt can be used instead of a chain, when necessary. Open inclined continuous bucket elevators are used in spite of the difficulties during rainy weather when the materials hang in the buckets and do not discharge properly. These elevators use either chain or belt. Normally, units of this kind are inclined 30° from the vertical, allowing the return run to sag (usually clearance permits this), and are not covered in any way or protected from the weather. The machinery for these elevators can be mounted on structural frames. The open inclined elevator are very rare because of the problems of being OSHA compliant.

2.14.4 Centrifugal-Discharge Elevator Buckets

The edges of all these buckets are reinforced for digging, and the bottom of these buckets is rounded. The various types of buckets used in centrifugal discharge elevators are described below.
1. AA buckets are made of malleable iron for chain or belt mounting. They have a reinforced lip for digging. They are the most common type in use for centrifugal discharge elevators.

2. AA-RB buckets are the same as the AA buckets, except that the edges are thicker. They are used for heavy service, and for abrasive materials.

3. AC buckets (table 2.12) are made for chain mounting. The hooded back allows a closer spacing of buckets.

4. B buckets (table 3.13) are cast malleable iron buckets for chain or belt mounting. They are used on inclined elevators for handling coarse materials such as stone. They will produce a clean discharge at low speed.

5. C buckets (table 2.14) are cast malleable iron for chain or belt mounting, and are used for finely pulverized or wet materials that tend to stick to buckets.

2.15 CONTINUOUS-BUCKET ELEVATORS

2.15.1 General

In the continuous-bucket elevator, buckets closely spaced on chain or belt are designed so that material is loaded directly into the buckets through a loading leg, instead of being scooped up in the boot. It is designed to operate at a low speed. The low operating speed and the method of loading and discharging minimizes breakage of fragile materials. These elevators are thus especially well adapted where degradation of the material is to be minimized and where extreme dust conditions are to be avoided. They will handle efficiently almost any kind of dry, fine, or small lump material that is not damp. Where lumps are over 2 in., or where the 2-in. lumps are over 10% of the capacity, super-capacity continuous-bucket elevators should be used. Feed inlet point of the continuous-type elevator is somewhat higher than that of the centrifugal elevator, necessitating a deeper pit when located below ground level. This elevator handles limestone, lime, cement, dry chemicals, and ferro-alloys. Such materials as fine salt, sand, clay, and many chemicals, dry or damp, should not, generally speaking, be handled by continuous-type elevators, as the fine particles get into the bottom of the bucket because of the V-shape. The particles clog there, will not discharge and finally, the material piles upon itself and gets hard in the bucket until very little capacity is left.

2.15.2 Speed

The speed of a continuous-bucket elevator on chain preferably should not exceed 150 fpm. If the material is not entirely free-flowing, the speed should be reduced to 100-125 fpm. When mounted on belts, and when inclined, the bucket speed may be increased up to about 200 fpm. Where highly abrasive materials are handled, reduced speeds are advisable. Generally, continuous-bucket elevators are equipped with chain. The use of belts is preferred where dusty, abrasive material can get to the chain joints.

2.15.3 Buckets

The buckets are not designed or intended to scoop material from the boot. Discharge of material over the head sprocket or wheel is accomplished by transfer of material from the discharging buckets to the front or bottom of the preceding bucket, which thus acts as a moving chute to the fixed discharge chute attached to the elevator casing (refer to paragraph 2.15.5).

The steel buckets on this type of elevator do not have a so-called round bottom like the type AA used on centrifugal elevators. The V shape of the bucket will fill up fast and the material will get hard, if damp or wet material is handled, thus reducing the actual capacity of the buckets. Some manufacturers install a filler plate
in the bottom of the V or y, either flat or curved. This may help a little, depending on the character of the material handled, but the possibility of material packing in this restricted area still remains.

The loading leg is used to direct material to buckets and is attached to the casing. It fits closely around the path of the buckets to prevent as much spillage of any fines in the material as possible, although some fine material will go to the bottom of the boot where it can be cleaned out at intervals. Any fines accumulating in the boot generally do not tend to hamper the operation of the elevator, and are usually scooped up by buckets if material does not get packed or hard. For material + 1 in., a loading leg should always be used.

The continuous-bucket elevator is quieter than the centrifugal discharge, especially when handling lumpy material.

2.15.4 Belts

Usually, when belts are used, the diameter of the head pulley is larger to prevent slipping. With a belt on a continuous elevator outdoors and not encased, the pulley must be lagged, or covered with a rubber covering known as "rough top brand," or with herringbone grooves cut into it, to get good contact with the belt.

When selecting a belt as an elevating medium, materials that pack and tend to build up between the belt and pulley, as well as rough or jagged particles which damage the belt by becoming lodged between buckets and belt, should be avoided. To some extent, these difficulties are alleviated through the use of wing pulleys on the foot shaft.

2.15.5 Types of Continuous Buckets

1. Type MF is a medium-front bucket that is not over lapping. It is the type most frequently used for continuous bucket elevators. Small flat or curved filler pieces are welded into buckets as shown. Refer to table 2.15 for capacity and weight.
2. Type HF buckets are made with a high front that is not overlapping. These buckets are used for higher capacities than medium-front buckets. Refer to table 3.16 for capacity and weight. Type LF buckets are low-front, not overlapping buckets, designed for inclined bucket elevators or to handle fine or damp materials that would stick or pack in buckets of other styles (refer to table 2.17).
3. Type HFO buckets are high-front overlapping buckets. They are similar to type HF high-front buckets but are made overlapping to prevent leakage between the buckets (refer to table 2.18).
4. Type D buckets are generally used for crushed stone plants or concrete plants located at construction sites (refer to table 2.19).

In summary, the MF, HF, and LF buckets are not the overlapping type, and are spaced on the chain or belt with about one in. between them so they will not foul each other because of poor assembly in the field. Such spacing is considered good practice and allows little leakage. The overlapping buckets are designed to actually fit into each other to prevent any leakage when discharging. All of the buckets described are currently made of welded construction; either spot welded or continuously welded, depending on the fineness of the material handled.

2.17 POSITIVE-DISCHARGE BUCKET ELEVATOR