# BUCKET CONVEYOR (ELEVATOR)



## 1. Main definitions

The term **elevator** is used to signify a group of materials handling equipment which carries materials up or down. The group includes a number of diverse type of equipment like bucket elevators, skip hoists, freight elevators, lifts etc. Some of these equipment have been discussed in this section.

**Definition, descriptive specifications and use:** These are powered equipment for conveying bulk materials in a vertical or steep inclined path, consisting of an endless belt, or chain/s to which metallic buckets are fixed. With the flexible belt/chain, the buckets move unidirectionally within a casing and collects bulk materials at bottom end of the equipment and delivers it at the top end.

A typical bucket elevator with different constructional parts is shown in Fig. 1. The different major parts constituting a bucket elevator are as follows:

(*i*) An endless pulling member- flat belt or chain.

(*ii*) Driving and take up pulleys or sprockets at top and bottom respectively, mounted on bearings and blocks.

(*iii*) Metal casing covering the entire elevator. It consists of **head** at the top, **boot** at the bottom and intermediate sections, all joined at flanges by fasteners.

(*iv*) Buckets, generally made out of sheet metal, which are attached at definite pitch to the pulling member by fastners (screw and nuts, riveted etc.)

(*v*) Drive at the top consisting of an electric motor, gearbox, and couplings.

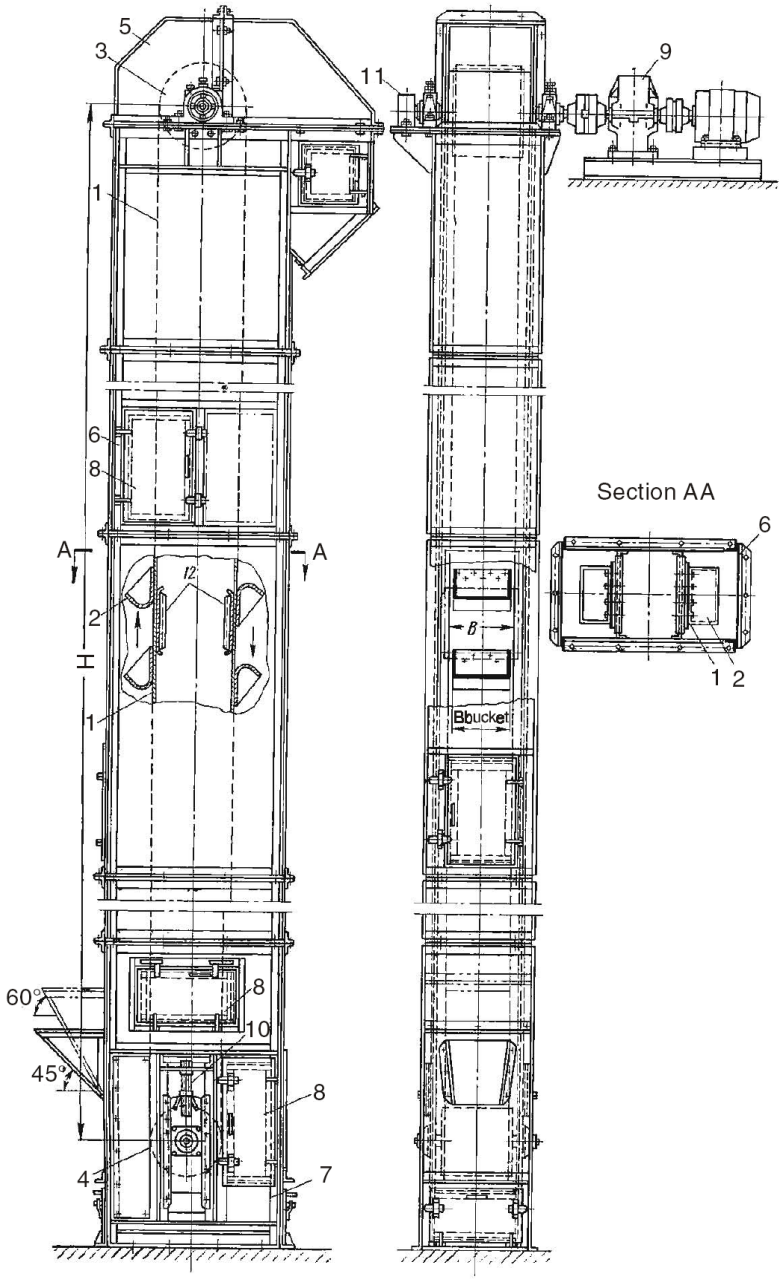
(*vi*) Hold back brake attached to the top pulley/sprocket shaft, to prevent reverse motion of the elevator when drive is stopped.

(*vii*) Feed hopper attached to the boot for feeding materials to the elevator.

(*viii*) Delivery/ discharge spout fixed with the top part of the casing, through which the material is discharged.

(*ix*) Manholes are provided at the casing to check operations of the elevator.

(*x*) Guides and guide sprockets are provided for belt and chain respectively to keep them in a straight path.




1-belt; 2-bucket; 3-driving pulley; 4-take-up pulley; 5-upper casing section; 6-intermediate casing sections; 7-lower casing section (boot); 8-manholes; 9-drive unit; 10-take-up; 11- holdback brake; 12-guides.

Fig. 1. A vertical belt-and-bucket elevator

Bucket elevator is a simple and reliable equipment widely used in process plants for lifting of bulk materials like lime stone, foundry sand, coke, coal, grain, dry chemicals and many more. Bucket elevators are generally low cost equipment requiring little floor space. However, bucket elevator is not suitable for large sized (100mm or above), hot or sticky materials because buckets are generally loaded by scooping action in the **boot** section and discharge from the buckets by centrifugal force or gravity. Chain type, with one or two chain, elevators are suitable for a speed range of 0.6 to 1.55 mps, while belt type are recommended to be used in a speed range of 1.15 to 2.85 mps.

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## 2. Types of bucket elevators

Bucket elevators are classified based on bucket spacing and mode of discharge of materials. As per IS:7167-1974, ‘‘Code for Selection and Use of Bucket Elevators,’’they are classified into following three basic types.

**Centrifugal discharge elevators (designated as type I):** In a centrifugal discharge elevator, the buckets are spaced at a regular pitch to avoid interference in loading and discharging. The charging of buckets is by scooping action and the discharge is by centrifugal action. These elevators are generally used in vertical configuration and used for practically all types of free flowing, small lump materials like grain, coal, sand, clay, sugar, dry chemicals etc. Both belt and chain may be used and the speed of these elevators range between 1.1 to 2 mpm. Buckets of the type A1, A2, A3 and A4 as per IS:6833-1973 are generally used. Fig. 2 illustrates the charging and discharging of buckets of this type of elevator.

**Positive discharge elevators (designated as type III):** These are similar to centrifugal discharge type excepting that the buckets are side-mounted on two strands of chains (i.e. buckets lie between two strands of chains), and are provided with a pair of two snub sprockets under the head sprockets to invert the buckets for complete discharge.

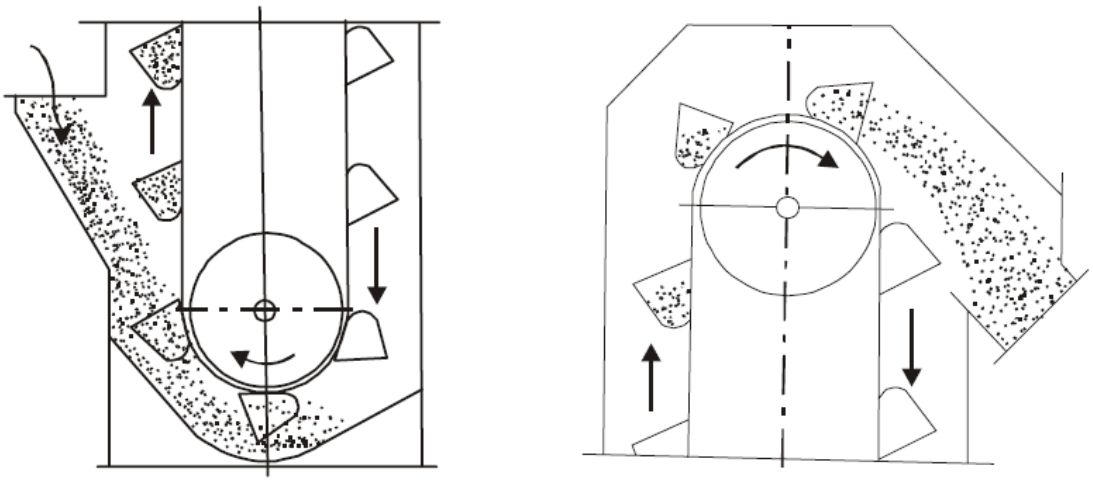


Fig. 2. Charging and discharging of buckets of centrifugal discharge elevator

The speed of the elevator may be slow in the range of 0.6 to 0.67 mpm. These elevators are used for light, fluffy, sluggish and slightly sticky materials. The feeding is through scooping or digging by the buckets. Fig. 3 shows the discharging of these elevators. An inclined elevator is particularly suitable for perfect gravity discharge.

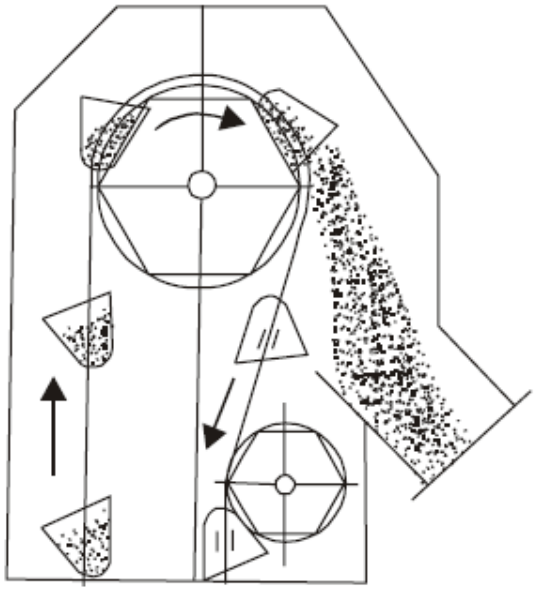


Fig. 3. Discharging of positive discharge elevator

**Continuous discharge elevators (designated as type II):** In these elevators, V-type buckets are used without any gap between them. These elevators

are employed for handling larger lumps and materials that may be difficult to handle by centrifugal discharge. The charging of the buckets are by direct filling. The discharge is by directed gravity i.e. when the buckets pass over head wheel, the flanged end of the preceding bucket act as a chute to deliver materials gently to the discharging spout. This type of charging and dischargeing is particularly effective for handling fragile materials. Bucket type B1, B2, B3 and B4 as per IS:6833-1973 is used for these elevators. Both belt and chain are used as pulling medium.

Speed is generally kept low. These elevators are used vertically or inclined. When inclined, special supports are provided for belt/chain in the return run, and wider casing is provided to allow for return run sag. Fig. 8.4.4 shows the charging and discharging of a continuous bucket elevator.

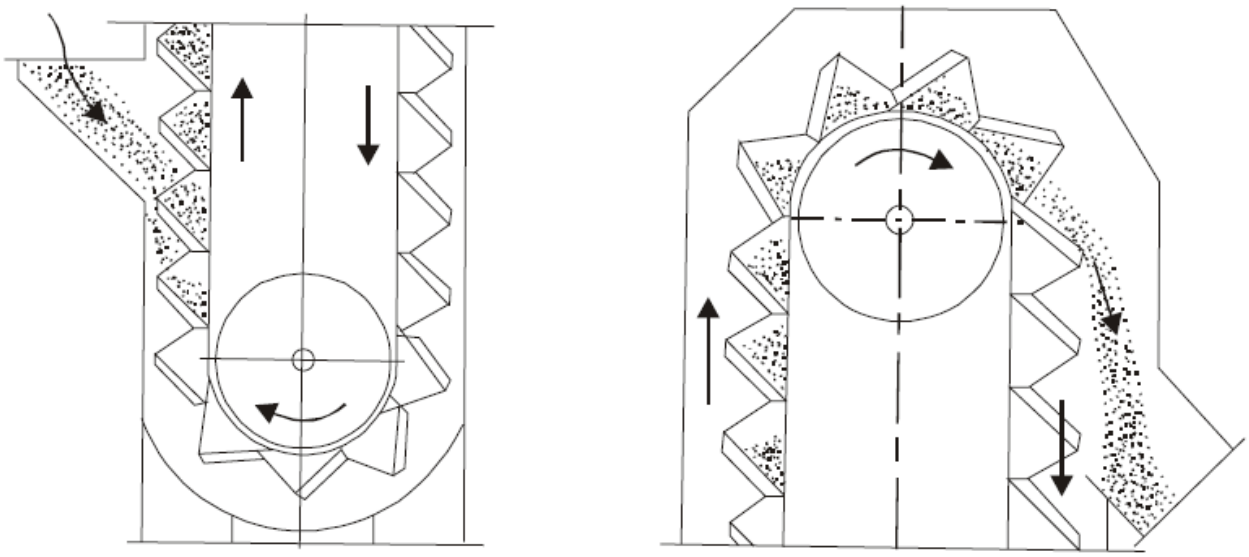
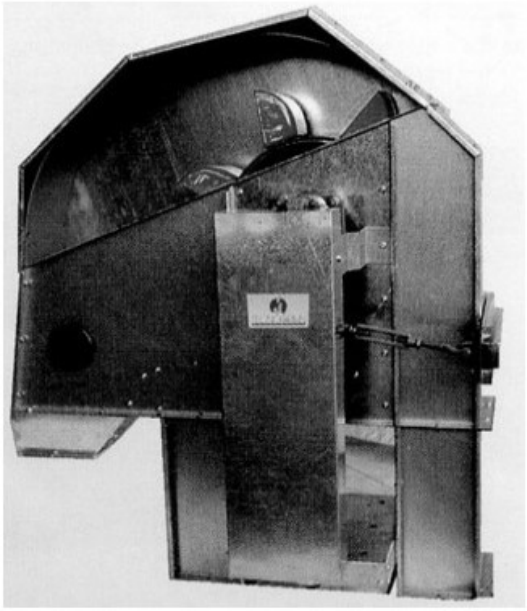


Fig. 4. Charging and discharging of a continuous bucket elevator

Fig. 5 shows photograph of head section (with part of cover removed) of a working bucket elevator.



**Selection of type of elevator:** Selection of type of bucket elevator depends primarily on materials to be handled. IS:7167-1974 recommends an elaborate list of different materials (123 in number) with the corresponding type of elevator to be selected and whether belt or chain to be used. Recommendation for only a few materials is shown in Table 1.

Table. 1. Recommendation for Selection of Bucket Elevators

| Materials | Bulk density, kg/m$^3$ | Belt /chain | Type of elevator (see note) |
|---|---|---|---|
| Alum, lumpy | 800-960 | Chain | I, III |
| Aluminum ore | 1200-1350 | Chain | I, III |
| Ashes | 560-640 | Chain | I |
| Bauxite, crushed and dry | 1200-1350 | Chain/belt | I, III |
| Carbon, black pelletized | 320-400 | Chain | III |
| Carbon, black powder | 65-100 | Chain | II |
| Cement, Portland | 1200-1350 | Chain | I, III |
| Chalk, pulverized | 1120-1200 | Belt / Chain | III |
| Coal anthracite | 960 | Chain/belt | I, III |
| Coke, loose | 370-510 | Belt | I |
| Gypsum calcined | 880-960 | Chain | I, III |
| Lime, ground | 960 | Chain | I, III |
| Lime, hydrated | 560-720 | Chain/belt | III |
| Malt, dry ground | 320-335 | Belt/ Chain | I, II |
| Rice, bran | 320 | Belt/ Chain | I |
| Salt, dry coarse | 720-800 | Belt/ Chain | I, III |
| Sand, damp | 1760-2080 | Belt/ Chain | I |
| Sand dry | 1440-1760 | Belt | I |
| Sugar raw | 880-1040 | Chain/belt | I |
| Talc | 800-960 | Belt | I |

Note to Table 1: I = Centrifugal discharge bucket elevator; II = Positive discharge bucket elevator; III = Continuous bucket elevator.

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### 3. Buckets for bucket elevator

The different components of a bucket elevator have been mentioned under ‘‘descriptive specification’’ in section 8.4.1 (A). The buckets used in a bucket elevator needs further elaborations. The buckets used are made as per BIS specification number IS:6833-1973 (reaffirmed 1996),‘‘Specification for Buckets for Bucket Elevators’’. The buckets are manufactured from suitable steel, aluminum or stainless steel sheet. The buckets may be cast also from malleable cast iron (IS:2107-1962 or IS:2108 -1962), cast steel, aluminum or even stainless steel castings. Buckets are classified into two types from consideration of their shape: Rounded bottom buckets are used in spaced bucket elevators and are classified as A1, A2, A3 and A4 type. V-type buckets are used in continuous bucket elevators, and are classified as B1, B2, B3 and B4 type. Fig. 5 illustrates geometrical features of the various types of buckets. Specified dimensions of these buckets namely length, projection, depth and capacity of the individual buckets are given in IS:6833-1973. Table 2 below indicates only the range of recommended dimensions of such buckets.

Table 2. Range of dimensions for buckets

| Bucket Type | Range of Bucket Size, mm | | | Capacity, litres | |
|---|---|---|---|---|---|
| | Length, mm | Projection, mm | Depth, mm | | |
| $A_1$ | 150 to 1000 | 95 to 250 | 100 to 260 | 0.87 to 36.50 | |
| $A_2$ | 150 to 1000 | 100 to 255 | 110 to 270 | 0.85 to 38.00 | |
| $A_3$ | 150 to 410 | 90 to 165 | 130 to 230 | 0.71 to 6.80 | |
| $A_4$ | 150 to 410 | 115 to 180 | 100 to 140 | 0.735 to 4.47 | **S dimension** |
| $B_1$ and $B_4$ | 150 to 610 | 75 to 300 | 145 to 460 | 0.81 to 41.0 | 20 to 50 for $B_1$ |
| $B_2$ | 150 to 610 | 75 to 300 | 145 to 460 | 0.81 to 41.0 | 20 to 50 |
| $B_3$ | 150 to 610 | 75 to 300 | 145 to 460 | 0.93 to 45.6 | |

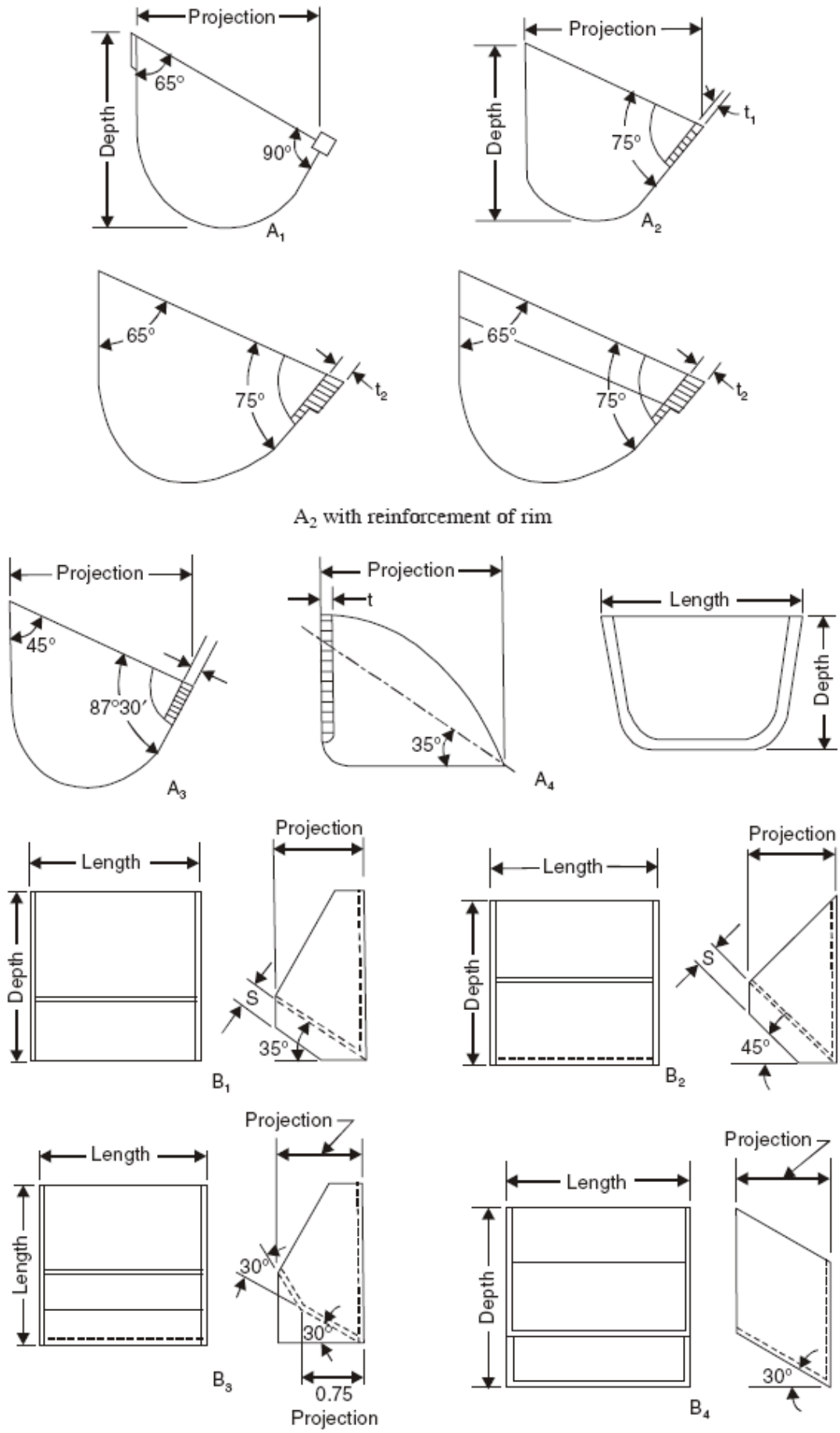
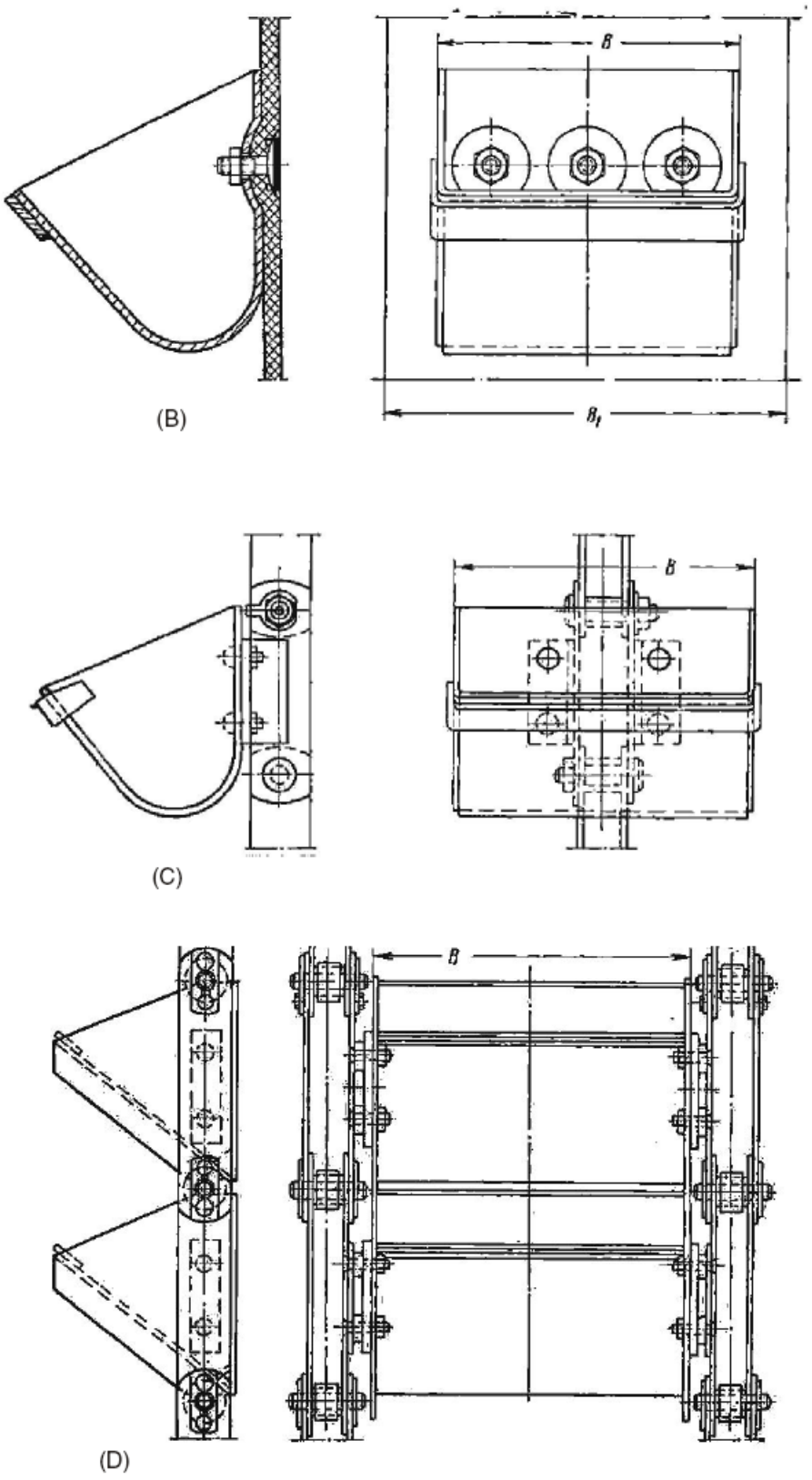



Fig. 5. Geometrical features of various types of buckets

Types A1, B1, B2, B3, B4 buckets are fabricated from sheet metal with joints welded or pressed. Types A2, A3 and A4 buckets are cast.




B-to belt; C-single chain; D-two chains to bucket side walls

Fig. 6. Typical bucket fixing arrangement

**Fixing arrangement of buckets:** The method of fixing of buckets to belt or chain is specified in IS:6930-1973 (reaffirmed 1996)- ‘‘Fixing Arrangement of Buckets for Bucket Elevators’’. The methods are designated by letters B, C and D as per following norms:

(*i*) Fixing of buckets to belt - B.

(*ii*) Fixing of buckets to chains passing through back of buckets - C

(*iii*) Fixing of buckets to chains passing through side of buckets - D

Typical bucket fixing arrangements are shown in Fig. 6.

**Selection of type of buckets:** The selection is based on the discharging method and materials to be conveyed. Recommendation of IS:7167-1974 is as given in the following table 3.

Table 3. Selection of Bucket

| Type of elevator discharge | Type of bucket IS:6833 | Recommended Application |
|---|---|---|
| Centrifugal and positive discharge | $A_1$ | For powdered and free flowing material. |
| | $A_2$ | For cement, coal, sand, gravel, stone, ores, fertilisers. |
| | $A_3$ | For wet, stingy materials. Also for coarse broken materials. |
| | $A_4$ | Sugar, clay, salt, wet ores. |
| | | |
| Continuous discharge | $B_1$ | For pulverized and sluggish materials that stick. |
| | $B_2$ | For average materials. |
| | $B_3$ | For large lumps and extra capacity. |
| | $B_4$ | For inclined elevators. |

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## 4. Capacity calculation

The discharge capacity ‘Q’ in tonne/hr. of a bucket elevator is given by the formula:

$$Q = \frac{C \times F}{1000} \times \frac{3600v}{s} \times \frac{\rho}{1000} \text{ tph}$$

where, C = capacity of each bucket, litres

F = bucket filling factor, a constant.

v = elevator speed, m/sec

s = bucket spacing, m

$\rho$ = material bulk density, kg/m$^3$.

Bucket filling factor indicates both loading and discharging efficiency of buckets for a particular application. Bucket filling factor 'F' varies between 0.85 for powdered materials to 0.4 for sluggish, moist materials. Following table 8.4.4, gives the values of 'F' to be considered in the above calculation, as recommended by IS:7167-1974.

Table 4. Bucket Filling Factor, F

| Material Characteristics | Type of Bucket Elevator | F |
|---|---|---|
| Powdered (ground) *e.g.* coal dust, cement, chalk, phosphate fertiliser etc. | Positive discharge<br>Centrifugal discharge | 0.85<br>0.75 |
| Granular and small lumped (60 mm) mildly abrasive *e.g.* saw dust, dry clay in lumps, coal peat, grain, etc. | Centrifugal discharge | 0.7 to 0.8 |
| Granular and small lumped (60 mm) highly abrasive *e.g.* gravel, ore, slag, sand, ash, earth, rock, etc. | Continuous discharge<br>Centrifugal discharge | 0.7 to 0.85<br>0.5 to 0.7 |
| Medium and large lumped (60 mm) highly abrasive *e.g.* crushed ore, stone, slag | Continuous discharge | 0.6 to 0.8 |
| Lumped, fragile, down graded by crushing *e.g.* charcoal, coke etc. | Continuous discharge | 0.6 |
| Slugglish, powdered and granular, moist *e.g.* moist chemicals, fluffed peat, earth, wet sand, wet powdered chalk etc. | Positive discharge<br>Centrifugal discharge | 0.4 to 0.6<br>0.4 to 0.6 |

The recommended bucket spacing 's' is also specified in IS:7167-1974, based on method of discharge and size of bucket used. For centrifugal discharge bucket elevators, it varies approximately between 2 to 3 times the depth of the buckets, while for positive discharge bucket elevators, it can vary between 3 to 5

times approximately. However, for continuous discharge elevators, it is kept marginally (10 to 20 mm) more than bucket depths, just necessary for fixing and to do maintenance to the buckets.

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