Reclamation Machine and Equipment

Dr. Emad Toma Karash Dr. Zaker Mohammed

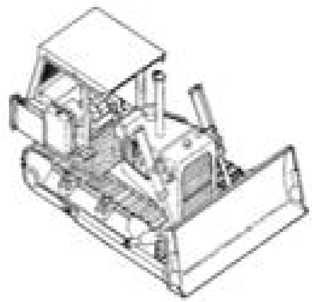
Sohel Yaihia Bathel

2014

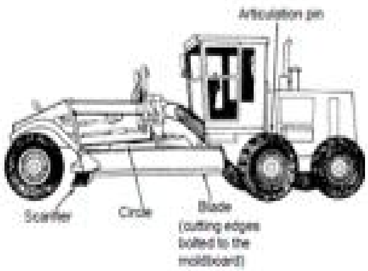
CONTENTS

Reclamation Machine and Equipment

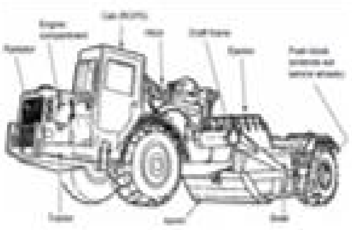
Dozers



Graders

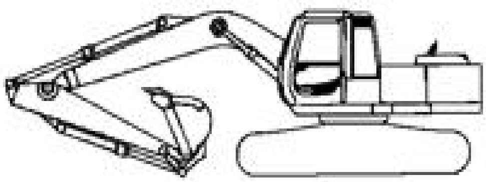


Scrapers

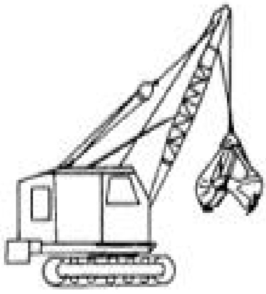


Loaders

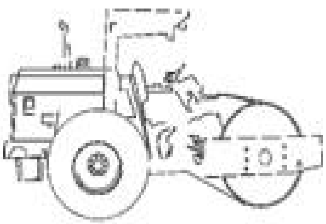
Excavators



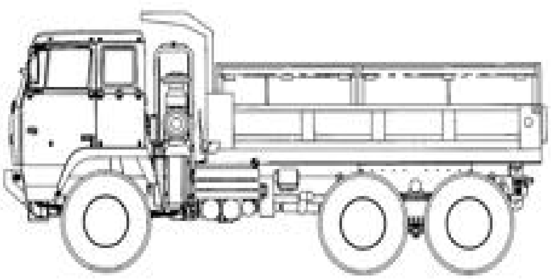
Cranes(will discuss another section)



Compactors



Dump Trucks

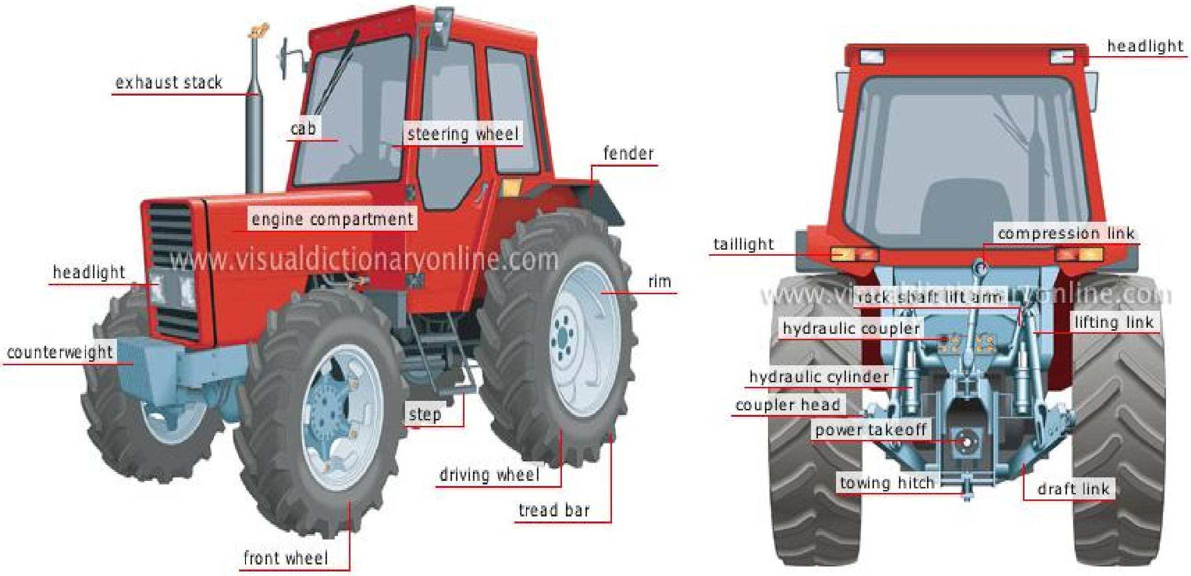


TRACTORS

Agricultural Machinery is any kind of machinery used on a farm to help with farming. The best-known example of this kind is the tractor. A special group is Self-Propelled Machinery.

A tractor is a heavy, high-powered vehicle that performs a variety of important jobs! For example, **tractors can be used in both farming and construction**. A farmer may use a tractor to get the soil ready for planting, while a tractor called a backhoe loader can both load and dig at construction sites. Some tractors even tow heavy items.

Tractors come in many different sizes. Some, such as compact utility tractors, are smaller models that people can use for yard work, while others are big enough to pull other large machines, figure shown the main parts of the Trator.



Before you start a tractor, you must know the basic safety procedures.

These are **safety checks** and **safe stop**.

Safety checks

1. Am I wearing suitable clothing and footwear?
2. Have I read and understood the instruction manual?
3. How am I going to do this work?

4. Have I carried out pre-start checks of the machinery?
5. Do I know enough to work safely?

Safe stop

1. Make sure the handbrake is fully applied.
2. Make sure all controls and equipment are left safe.
3. Stop the engine.
4. Remove the key.

Always use **safe stop**:

1. before leaving your seat; or
2. when anyone else approaches; or
3. when anyone else is working on the machine.

Below are different types of tractor implements you may need:

- **Box scrapers or box-blades** – are tractor implements used to level the area in preparation for building. They are pulled behind a tractor when performing the task.
- **Back hoes** – these tractor attachments are a piece of excavating equipment or digger consisting of a digging bucket on the end of a two-part articulated arm. This is usually used in making drainage system or irrigation.
- **Wood-chippers** – are tractor implements used for reducing wood (generally tree limbs or trunks) into smaller pieces, such as wood chips or sawdust. They are usually portable, being mounted on wheels on frames appropriate for towing behind a truck or van.
- **Top-dressers** – used for applying a fine layer of 'home mixed quality soil' to the lawn surface.
- **Utility trailers** – are a transport conveyance, without a motor or an engine, utilized for carrying loads. They are designed to be pulled by a vehicle that is powered by an engine, such as a tractor.

Type/Performance Characteristics of Tractors

. Tractors are classified on the basis of running gear:

1. Crawler (track laying) type (see Fig 1)
2. Wheel type (see Fig 2)
    - **a.** Single axle -usually part of a unit such as a scraper or bottom dump
    - **b.** Two-axle single axle drive; two -axle drive

Fig. 1

Fig. 2

Crawler tractors

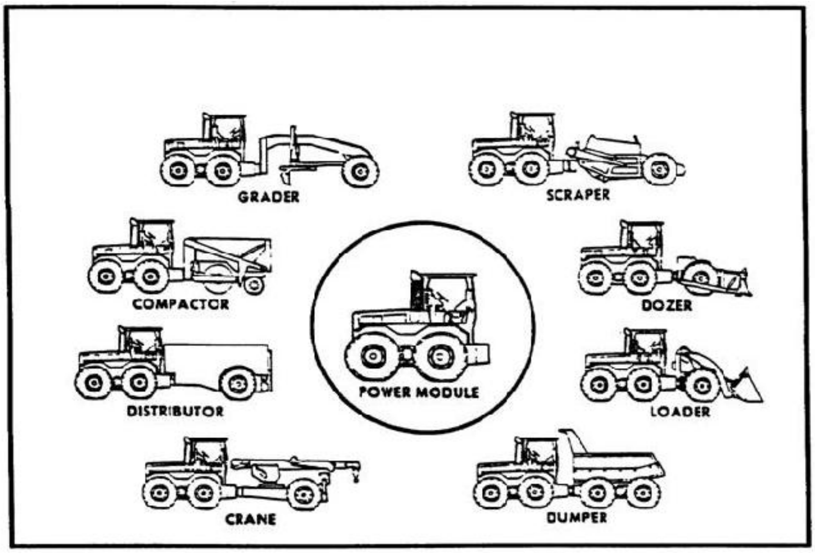
The crawler track type unit is designed for those jobs requiring high tractive effort. They are usually rated by size or weight and power. The weight is important on many projects because the maximum tractive effort that a unit can provide is limited to the product of the weight times the coefficient of traction for the particular road surface regardless of the power supplied by the engine. Table 1.4 gives the coefficients of traction for various surfaces.

An advantage of wheel-type tractors as compared with a crawler tractor is the higher speed that is possible with the former tractors in excess of 30 mph for some models However, in order to attain a higher speed, a wheel tractor must sacrifice pulling effort Also, because of the lower coefficient of traction between rubber tires and some soil surfaces, the wheel tractor may slip its wheels before developing its rated pulling effort.

Tractor-type utilization comparison		
NO.	Wheel tractor	Crawler tractor
1	Good on firm soils and concrete and abrasive soils which have no sharp-edged pieces	Can work on a variety of soils. Sharp-edged pieces not as destructive to tractor though fine sand will increase running gear wear
2	Best on level and downhill work Wet weather, causing soft and slick surfaces will stop operation.	Can work almost any terrain Can work on soft ground and over mud-slick surfaces: will exert very low ground pressures with special wide tracks and flotation track shoes
3	The concentrated wheel load will provide compaction and kneading action	
4	Good for long travel distances	Good for short work distance
5	Best in loose soils	Can handle tight soils
6	Has fast return speeds, 8-20 mph	Slow return speeds, 5-7 mph
7	Can only handle moderate blade loads	Can push large blade loads

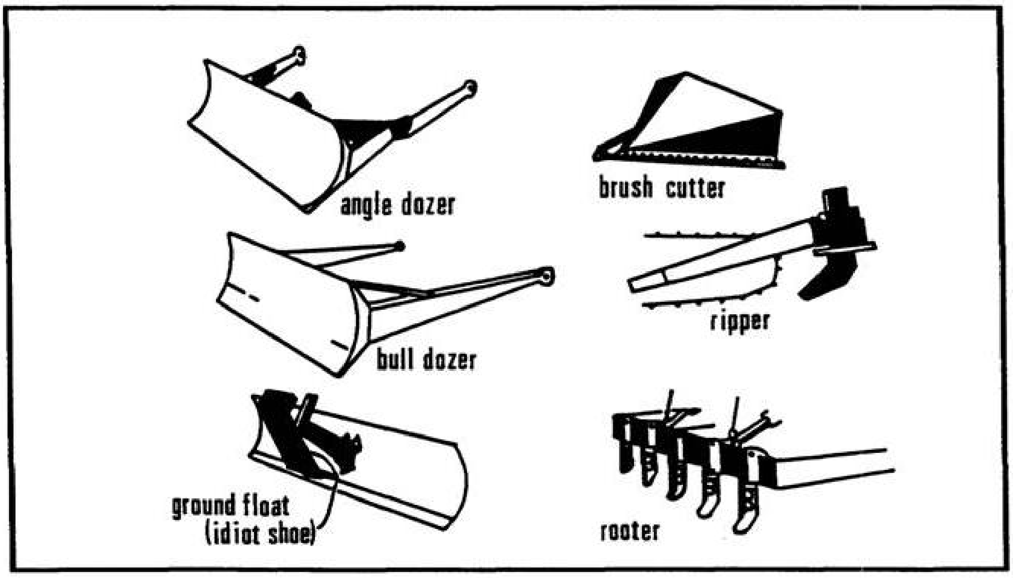
Famece Power Module and Work Modules Explained

Famece Power Module and Work Modules identification and nomenclature: power module, grader, scraper, dozer, loader, dumper, crane, distributor, compactor.



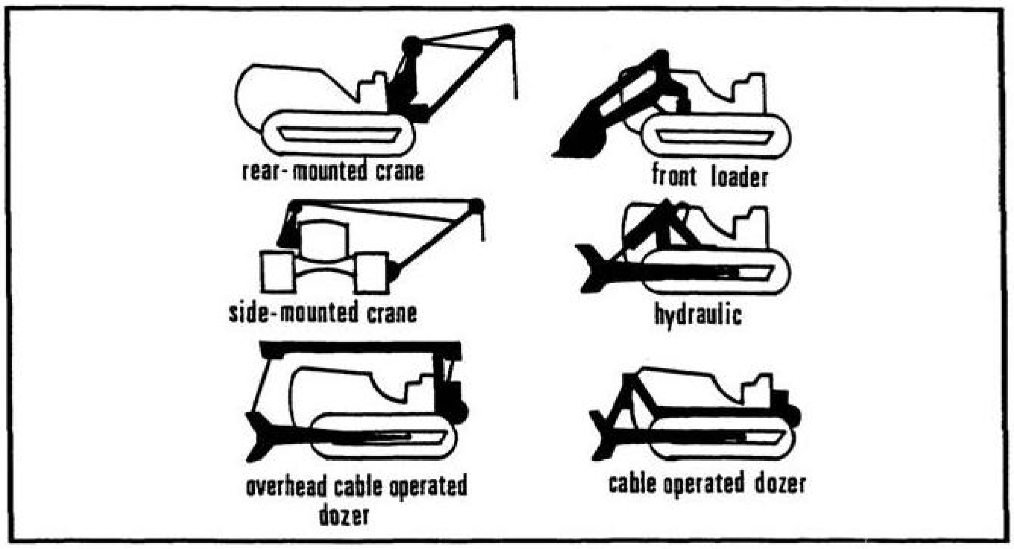
Tractor Types and Its Name

A diagram consists of different types of tractor's attachments: angle dozer, brush cutter, ripper, bull dozer, ground float (idiot shoe), rooter.



Tractor's Attachments and Its Nomenclature

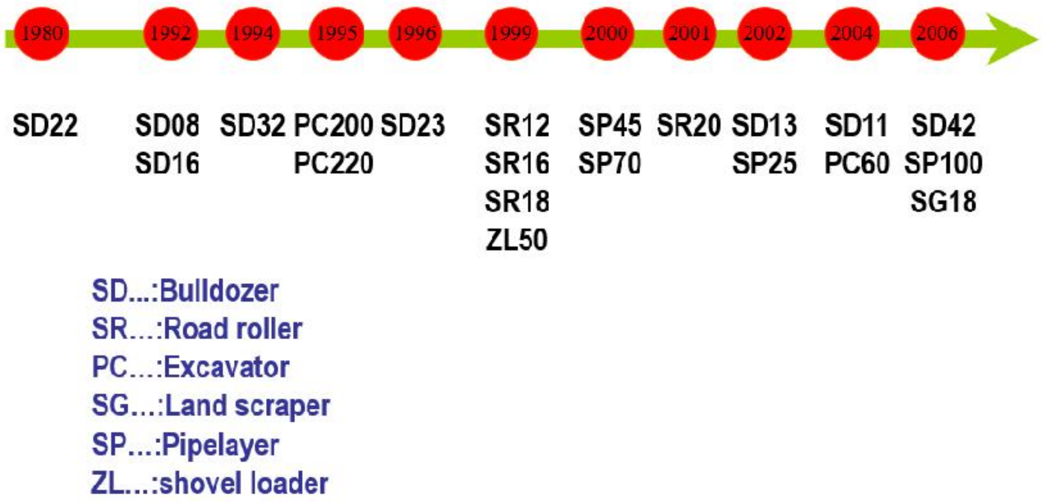
Picture depicts tractor types along with its name: rear mounted crane, side mounted crane, front loader, hydraulic, cable operated dozer, overhead cable operated dozer.



BULLDOZERS

In 1923, a young farmer named James Cummings and a draftsman named J. Earl McLeod made the first designs for the bulldozer. A replica is on display at the city park in Morrowville, Kansas where the two built the first bulldozer. On December 18, 1923 • Over the years, bulldozers got bigger and more powerful in response to the demand for equipment suited for ever larger earthworks.

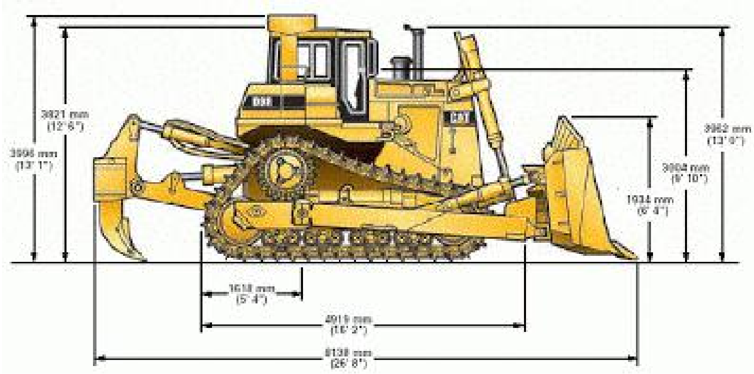
History of SHANTUS produced



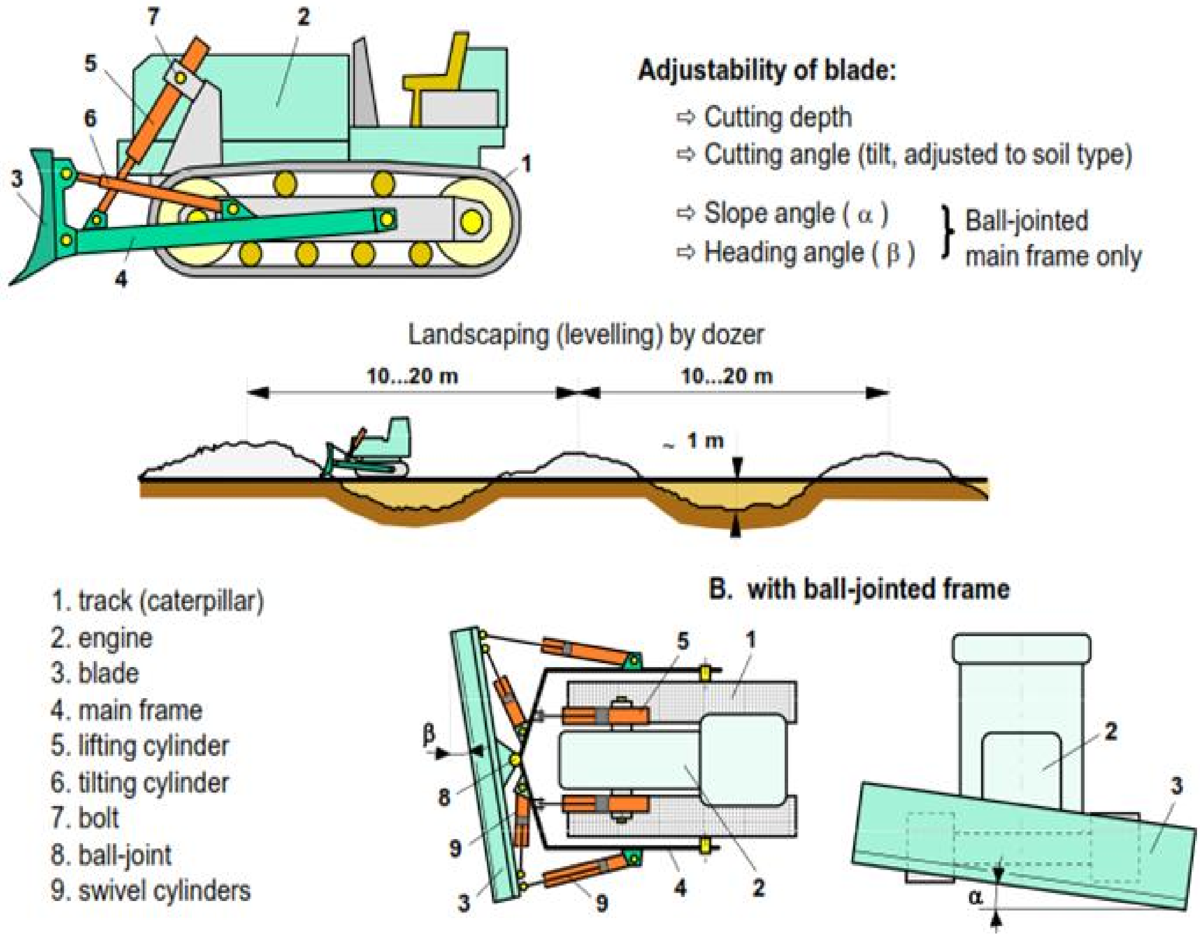
A bulldozer is a tractor unit which has a blade attached to its front. That is the meaning used here Bulldozers are heavy equipment capable of moving heavy loads, clearing rubble, and are very helpful in civil engineering and agriculture works. Modern bulldozers are no uglier and too heavy to handle. They are equipped with electronic devices and they look good, too.

A bulldozer is a crawler (continuous tracked tractor) equipped with a substantial metal plate (known as a blade) used to push large quantities of soil, sand, rubble, or other such material during construction or conversion work and typically equipped at the rear with a claw-like device (known as a ripper) to loosen densely- compacted materials.

• The term "bulldozer" is often used erroneously to mean any heavy equipment (sometimes a loader and sometimes an excavator), but precisely, the term refers only to a tractor (usually tracked) fitted with a dozer blade. That is the meaning used here



The blade is used to push, shear, cut, and roll material ahead of the tractor. The bulldozer is an effective and versatile earthmover Bulldozers are used as both support and production machines on many construct ion projects.



Where they may be used from start to finish for such operations as

1. Clearing land of timber stumps
2. Opening up pilot roads through mountains and rock terrain
3. Moving earth for short-haul distances, up to about 300 it
4. Helping to load tractor-pulled scrapers
5. Spreading earth and rock fills
6. Clearing the floors of borrow and quarry pits
7. Backfilling trenches

Bulldozer Manufacturers.

There are various manufacturers of bulldozers worldwide.

The following is a partial list of companies in the United States that manufacture bulldozers or bulldozer attachments. This list is for reference only. Inclusion or omission of a manufacturer from this list does not imply endorsement by the Department.

NO.	Manufacturer	Location
1	Case	Racine , WI
2	Caterpillar	Peoria , IL
3	Dresser	Springfield , OH
4	John Deere	Moline , IL
5	Komatsu	Galion , OH
6	Terex	Tulsa , OK
7	VME Americas Inc.	Cleveland , OH

TYPES OF BALLDOZERS

1. Crawler (track laying) Tractor
2. Wheel Type Tractor

a) Single-axle

b) Two-axle

1. Single axle drive

2. Two axle drive

BALLDOZERS USES

1. Dozers (Tractors) are self-contained units that are designed to provide tractive power for drawbar work.
2. Consistent with their purpose as a unit for drawbar work, they are low center of gravity machines. This is a prerequisite of a good machine.
3. The larger the difference between the line of force transmission from the machine and the line of resisting force the less effective the utilization of developed power.

Typical project applications are:

1. Land clearing

2. Dozing (pushing materials)

3. Ripping

4. Towing other pieces of construction equipment

5. Assisting scrapers in loading.

DESCRIPTION

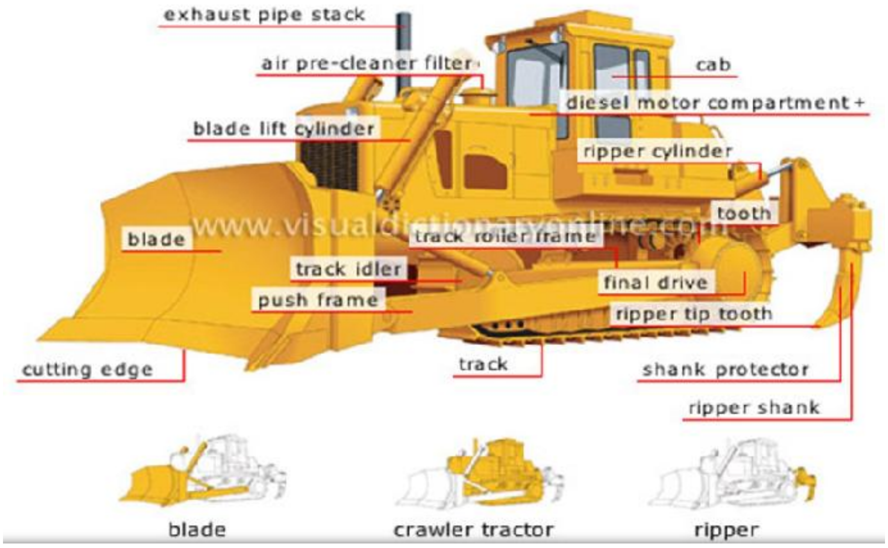
Most often, bulldozers are large and powerful tracked heavy equipment. The tracks give them excellent ground hold and mobility through very rough terrain. Wide tracks help distribute the bulldozer's weight over a large area (decreasing **pressure**), thus preventing it from sinking in **sandy or muddy** ground. Extra wide tracks are known as 'swamp tracks' or "LGP (low ground pressure)tracks". Bulldozers have excellent ground hold and a **torque** divider designed to convert the engine's power into improved dragging ability. The

Caterpillar D9, for example, can easily tow **tanks** that weigh more than 70 tons. Because of these attributes, bulldozers are used to clear areas of obstacles, shrubbery, burnt vehicles, and remains of structures.

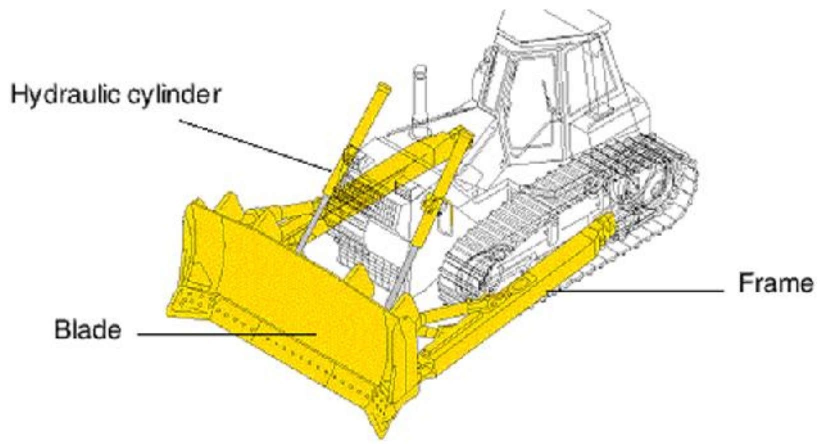
Bulldozer Assembly

1. Power take-off
2. Torque converter
3. Universal joint
4. Transmission unit
5. Main drive
6. Steering brake
7. Final drive
8. Track equipment
9. Control system
10. Working equipment
11. Cabin
12. Floor and Fender
13. Track frame

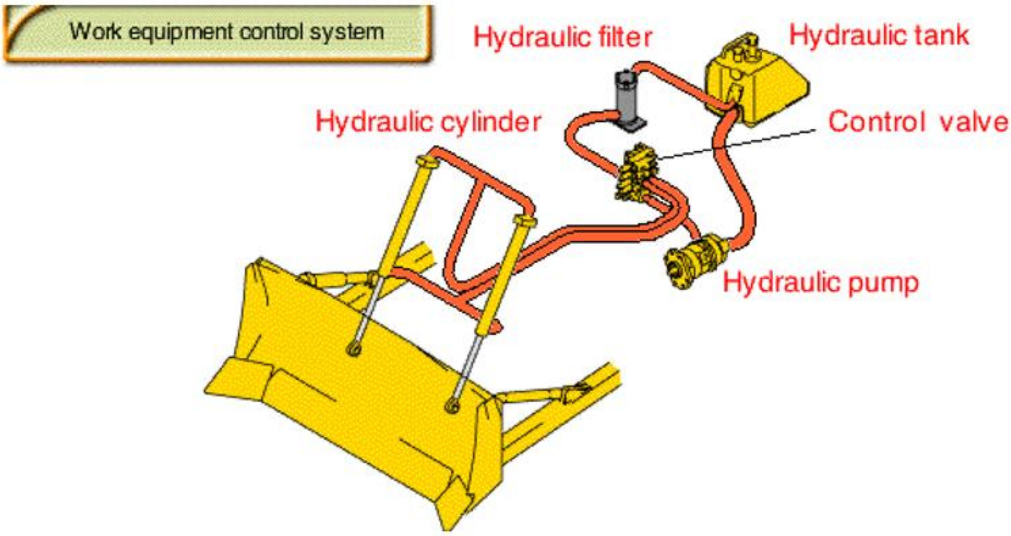
THE BULLDOZER'S PRIMARY TOOLS



Work equipment



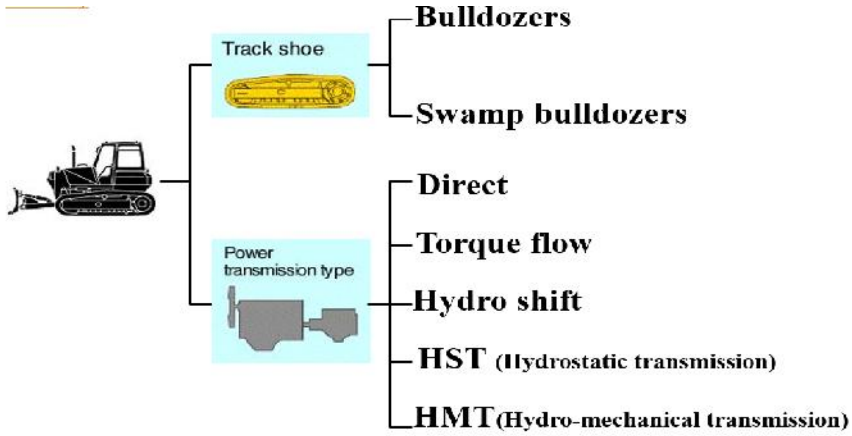
Work equipment control system

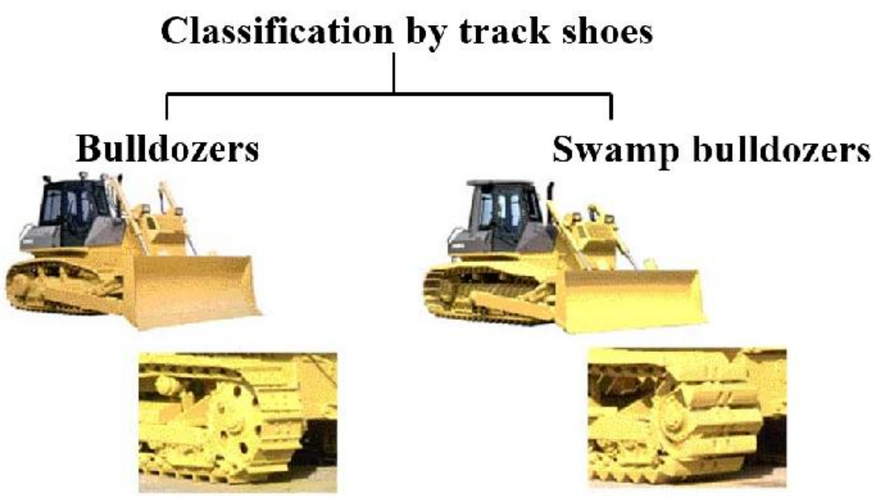


Power train

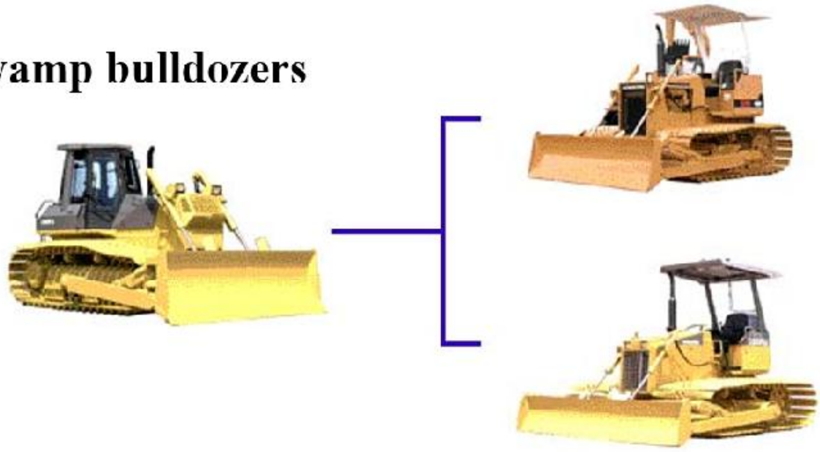
Engine → Torque converter → Universal joint → Gear box→ Main drive → Steering clutch → Final drive → Track system .

Classification of Bulldozer



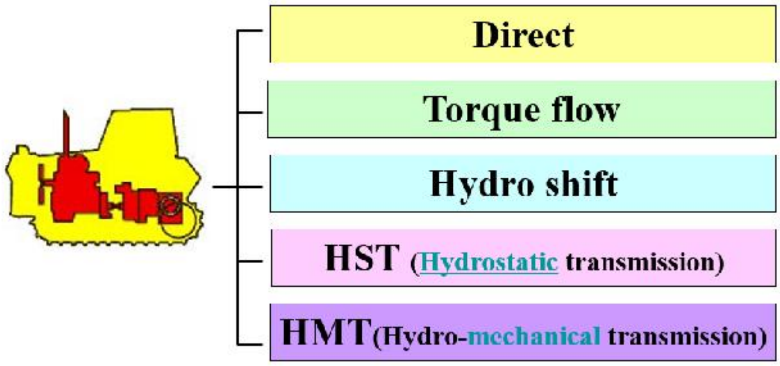


Swamp bulldozers



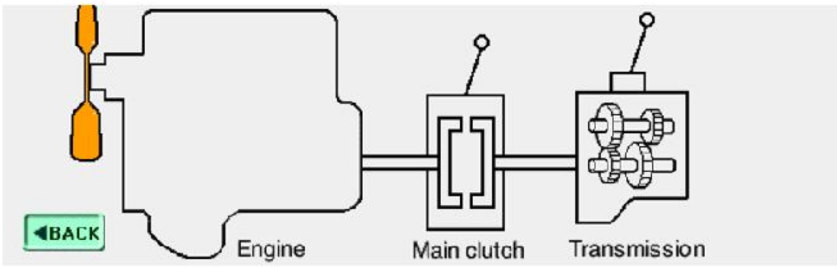
Super swamp bulldozers
(for extremely soft terrain)

Classification of Bulldozer of Power Transmission



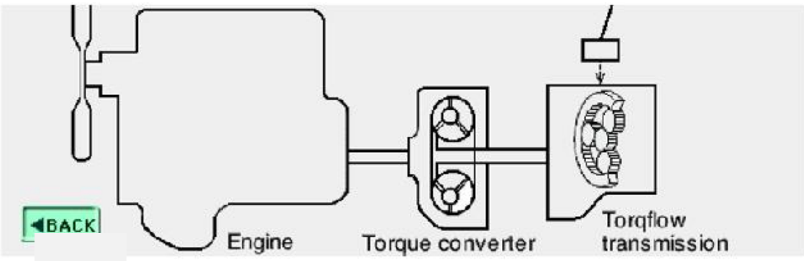
1. Direct drive

Advantage	Disadvantages
➢Power transmission efficiency is high.	➢Gear shifting operation is complicated. ➢Engine stalls is overloaded. ➢Power transmission is interrupted when shifting gears. ➢Engine output fluctuates according to load.



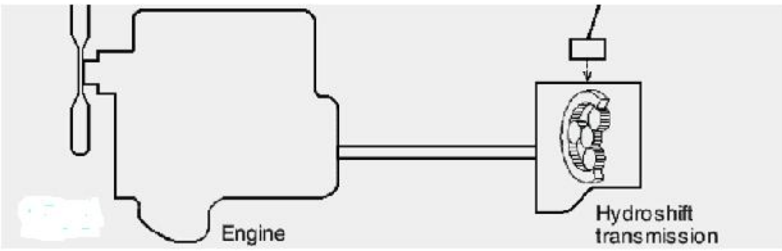
2. Torque flew drive

Advantage	Disadvantages
➢Gear shifting operation is easy. ➢Engine does not stall even if overload. ➢Less interruption of power transmission when shifting gears.	➢Power transmission efficiency is low. ➢More expensive than direct drive machine.



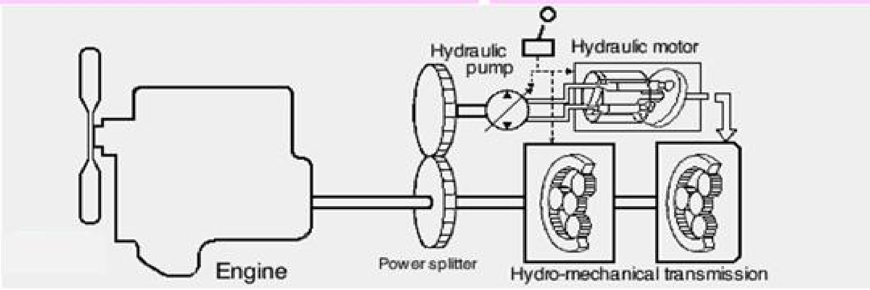
3. Hydro shift drive

Advantage	Disadvantages
➢Gear shifting operation is easy. ➢Power transmission efficiency is high. ➢ Less interruption of power transmission when shifting gears.	➢engine stalls if overload.



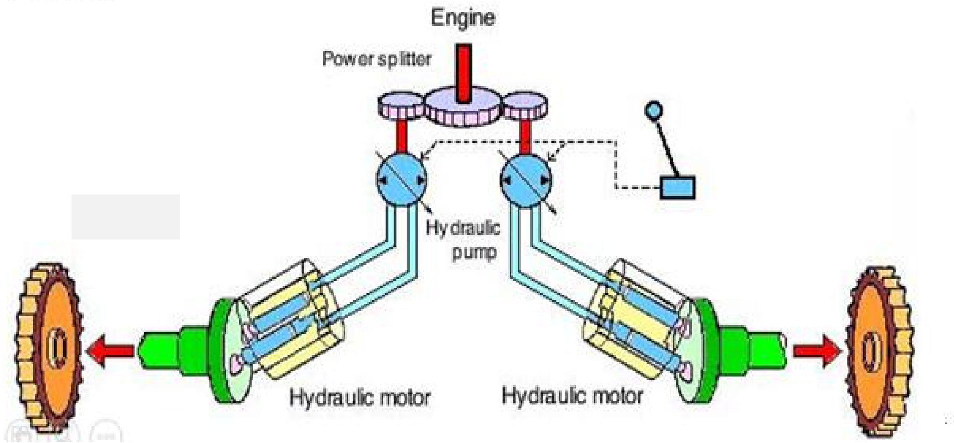
4. HMT (Hydro – Mechanical Transmission)

Advantage	Disadvantages
➢Power transmission efficiency is high. ➢Gear shifting can be automated. ➢Engine does not stall even if overload. ➢Engine output is kept constant under any load.	➢More complicated structure than torque flew drive.

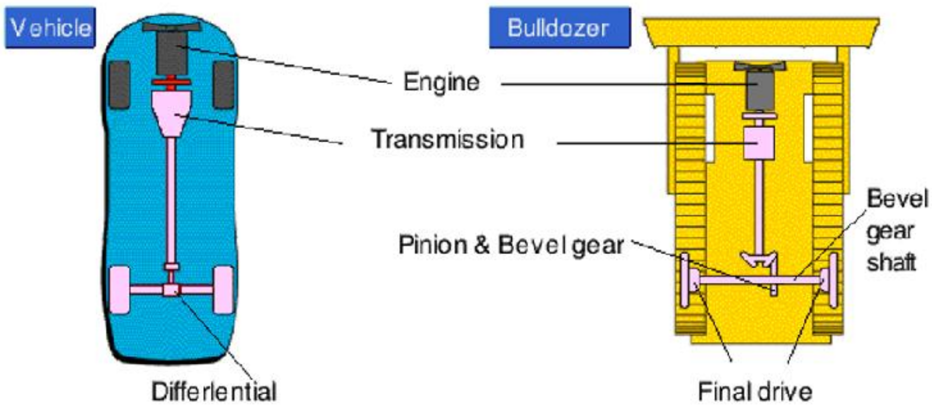


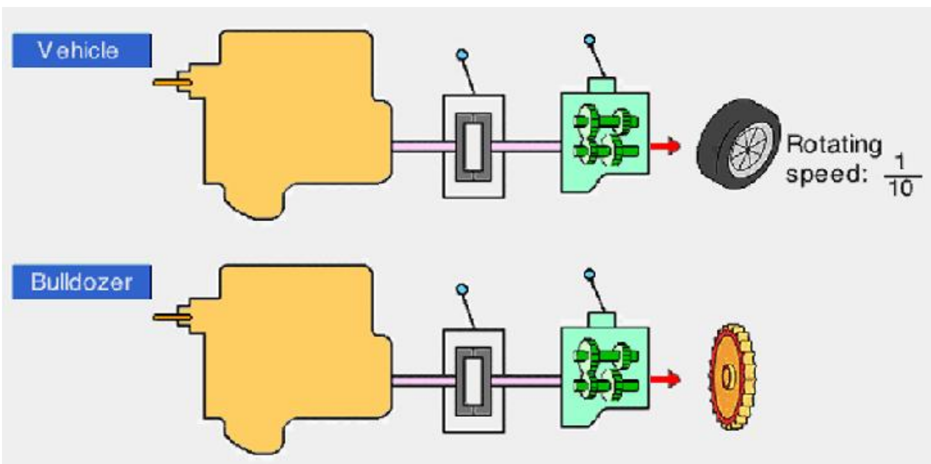
5. HST (Hydrostatic Transmission)

Advantage	Disadvantages
➢Gear shifting is not required. ➢Engine does not stall even if overload. ➢Power transmission is not interrupted due to the continuous speed control. ➢Maximum output range of engine can be always used.	Power transmission efficiency is very low.

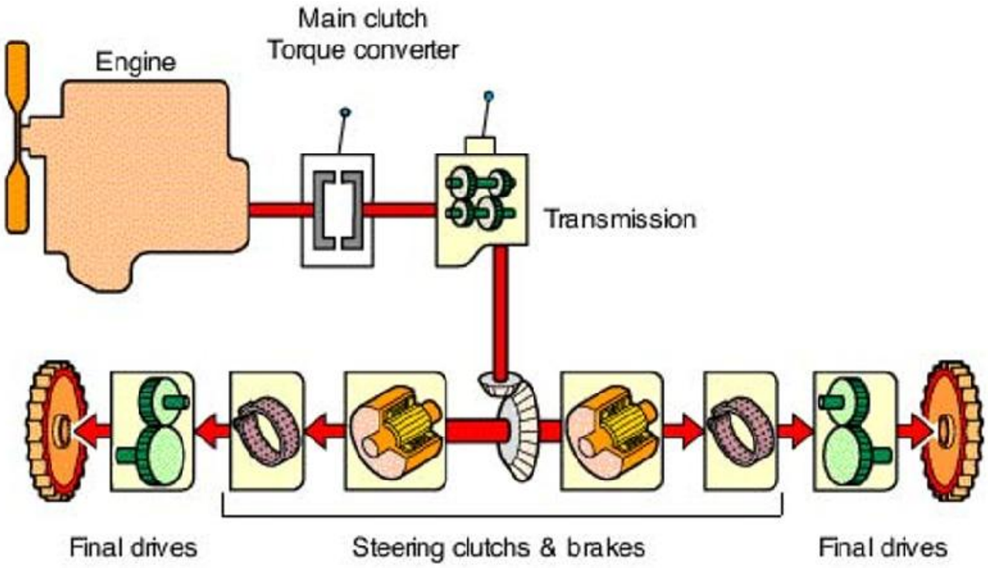


Comparison of power transmission system





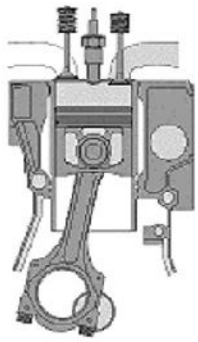
Power transmission



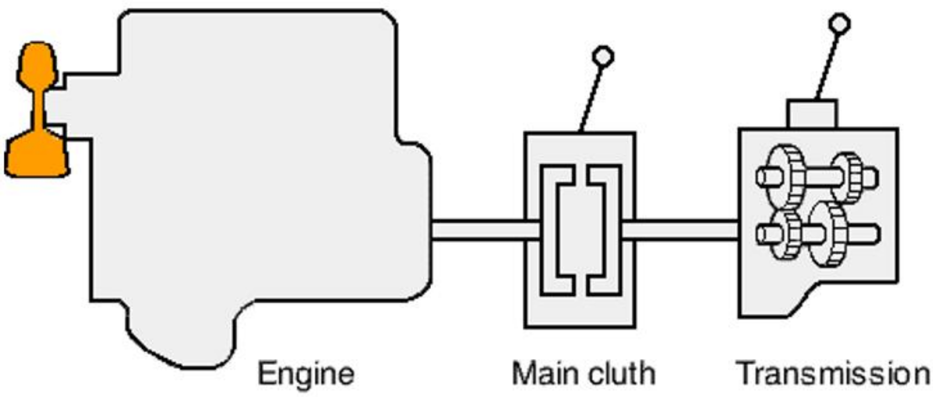
Engine

Diesel engine for bulldozer

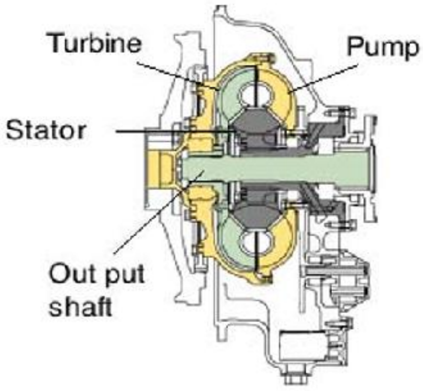
SD16 STEYR WD615 T1-3A or SHANGCHAI D6121 120kw (160HP)/1900rpm
SD22 CUMMINS NT855-C280 162kw(220HP)/1800rpm
SD32 CUMMINS NTA855-C360 235kw(320HP)/2000rpm

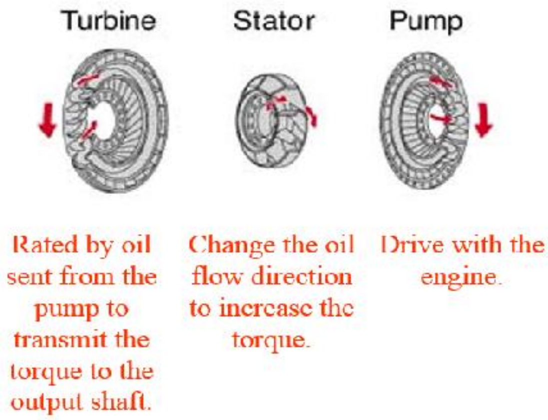


Main clutch



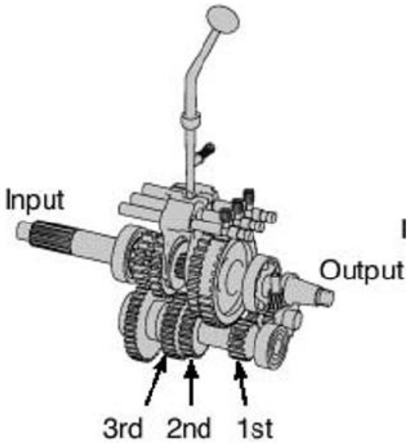
Torque converter



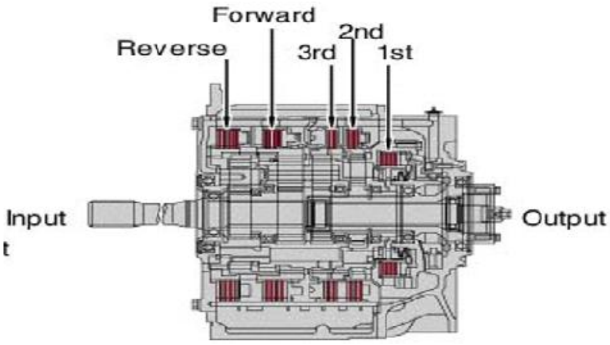


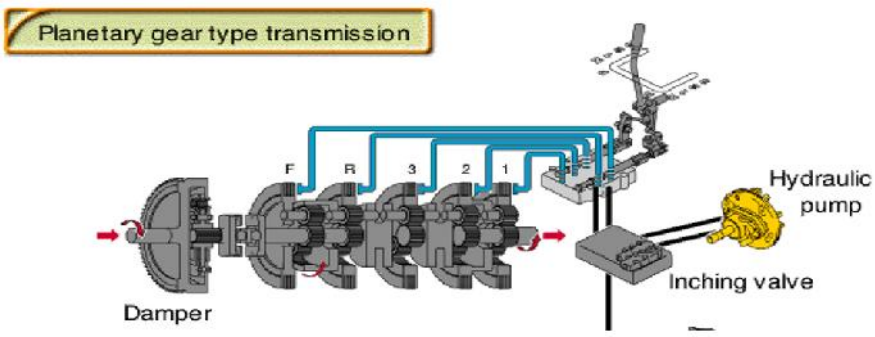
Transmission

1. Direct transmission (sliding mesh type)



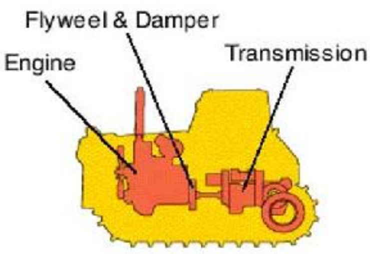
2. Planetary gear type transmission

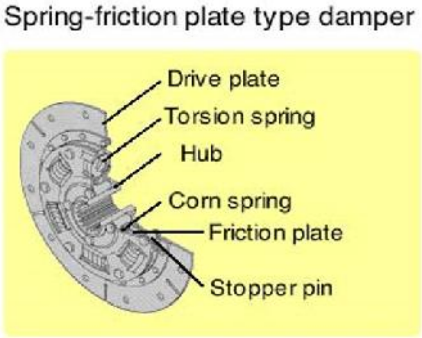




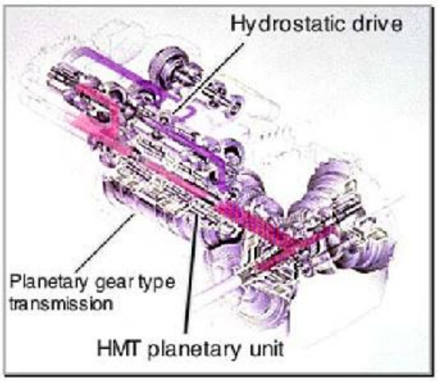
Notes

1. This form is used in SD08

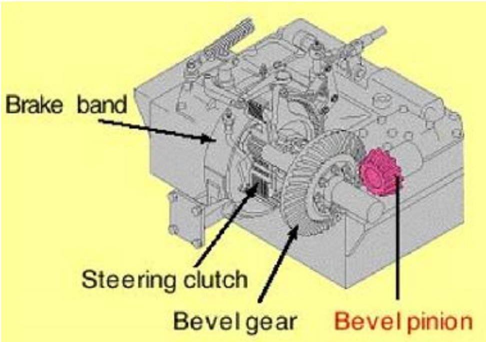




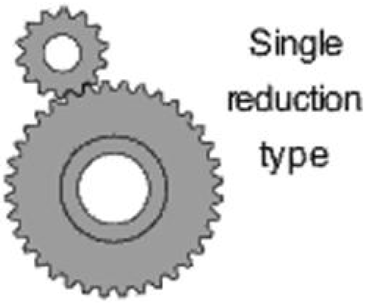
2. This form is used in SD32C

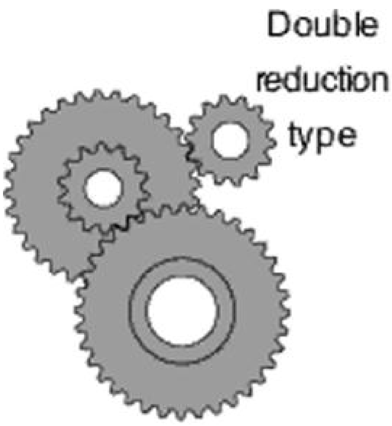


Bevel gear shaft



Final drive





BLADES

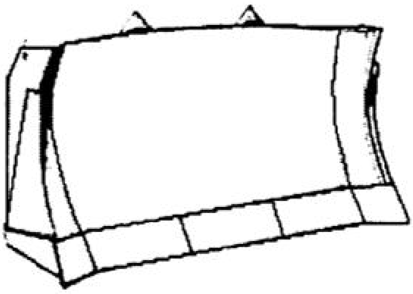
The bulldozer blade is a heavy metal plate on the front of the tractor, used to push objects, and shoving sand, soil and debris**.**

Types of blades : -

a. Straight ‘S’ blade
b. Universal ‘U’ blade
c. Angle ‘A’ blade
d. Cushion ‘C’ blade
e. Rake

a. Straight ‘S’ blade

1. Used for heavy work
2. Most versatile bulldozer
3. Equipped with a push plate effectively used for loading scraper
4. Most blade are curved, but the section perpendicular to the line of push is straight
5. The maximum of push should not exceed 100m as the machine is uneconomical for earth moving over a greater distance

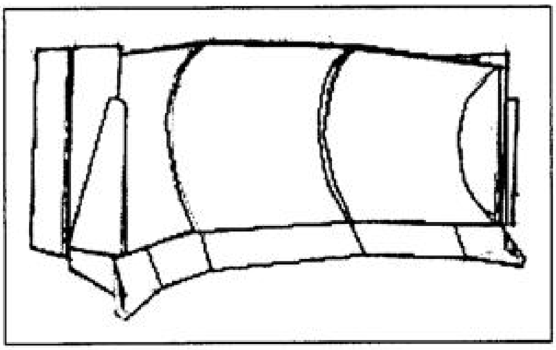



a. ‘S’ Straight Blade

b. Universal ‘U’ blade

1. The blade in cross-section has a much deeper curvature, almost a ‘u’ shape.
2. Efficient for moving big loads over long distance as in land clearing, stockpile work and pushing up for loading

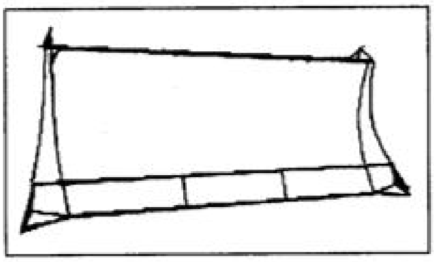
3. Shall combined with a tilt cylinder to improves its ability to ditch, pry out and level
4. Effecting to light flowing type of soil



b) “U” Universal Blade

c. Angle ‘A’ blade

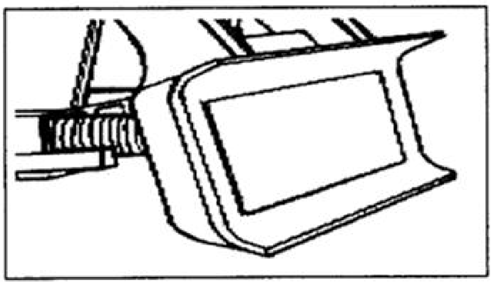
1. The blade in plain view is angled
2. Can also be positioned straight or angled 25 degrees to either side
3. Designed for side casting, backfilling and other similar tasks
4. Can reduce the amount of manoeuvring required to do this job



c. Angle ‘A’ blade

d. Cushion ‘C’ blade

1. Used on a large tractors for on-the-go push loading
2. Rubber cushion allow the dozer to absorb the impact of contacting a scraper push block and effective travelling speed is up to 5 km/h
3. When not push loading, the dozer can be used for general dozing jobs



d) Cushion Pusher Plate

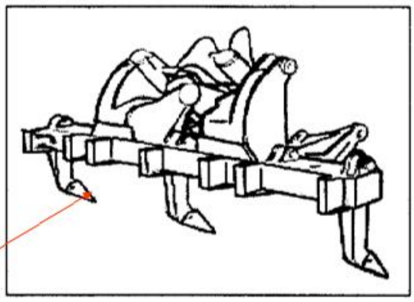
Blade Specifications

Blade Type	Capacity	Overall Width	Height	Digging Depth	Ground Clearance	Maximum Tilt	Weight	Total Operating Weight
Semi-U	25.4 m³ 33.1 yd³	6321 mm 20.75 ft	2179 mm 7.2 ft	398 mm 1.3 ft	1540 mm 5.04 ft	1165 mm 3.8 ft	10 161 kg 22,400 lb	98 488 kg 217,128 lb
Heavy-duty Semi-U	25.4 m³ 33.1 yd³	6321 mm 20.75 ft	2179 mm 7.2 ft	398 mm 1.3 ft	1540 mm 5.04 ft	1165 mm 3.8 ft	10 750 kg 23,700 lb	99 077 kg 218,427 lb
Coal	44.7 m³ 58.2 yd³	7200 mm 23.6 ft	2500 mm 8.2 ft	398 mm 1.3 ft	1540 mm 5.04 ft	1706 mm 5.6 ft	10 333 kg 22,780 lb	98 660 kg 217,507 lb

Semi-U Blade: This unit combines the characteristics of an S and U blade into one package. It has increased capacity by the addition of short wings which include only the dozer end bits.

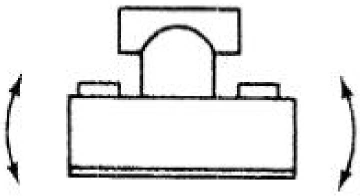
e. Rake

1. A blade consisting a heavy duty ribs which retained coarse rock, roots etc, but allow finer material to pass through
2. Used in digging and pushing stumps and rock and also in spreading of rock rip-rap



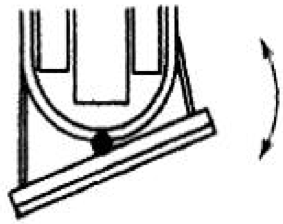
Rib

Common types of Bulldozer blades



Tilting

Pitching

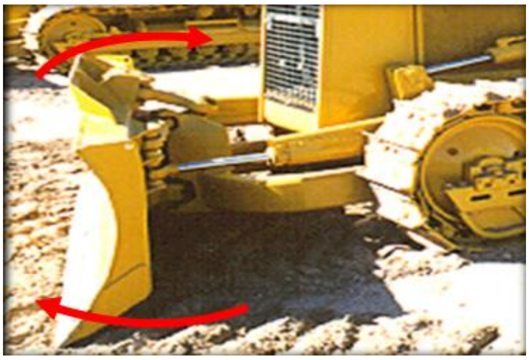


Angling

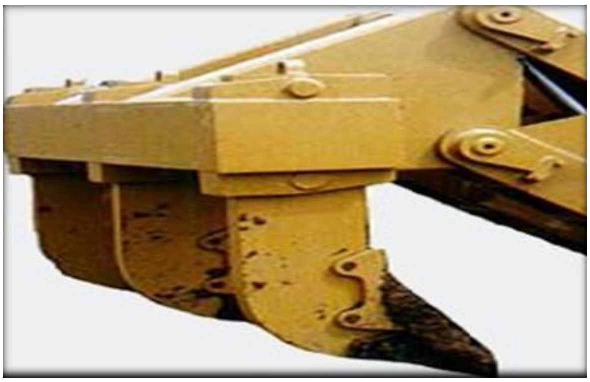
BLADE ADJUSTMENTS

1. **Tilting**

2. **Angles**



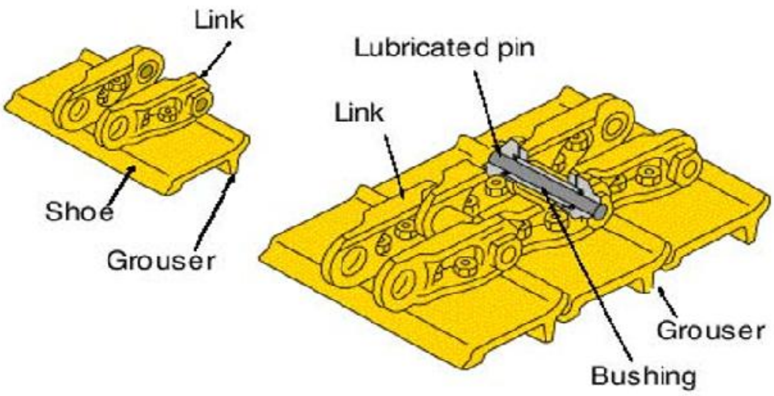
3. **Ripper**

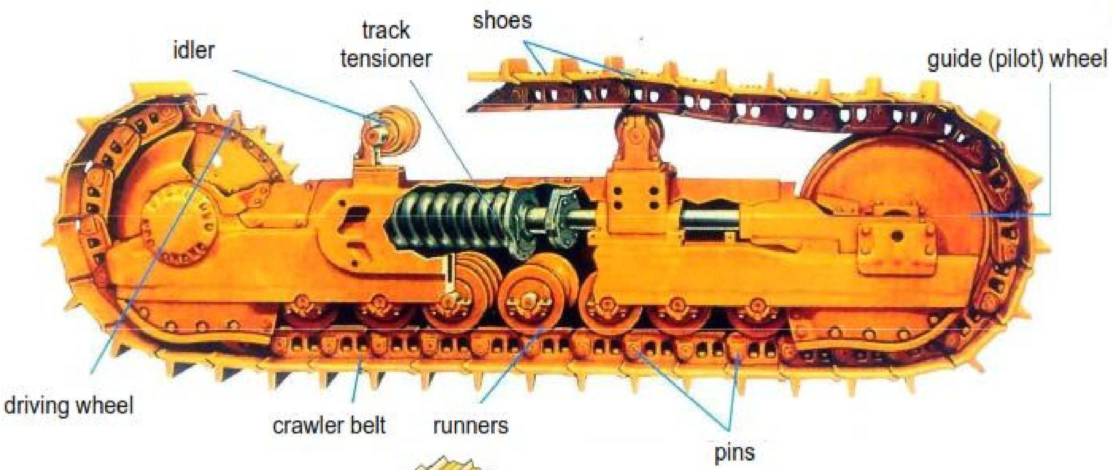


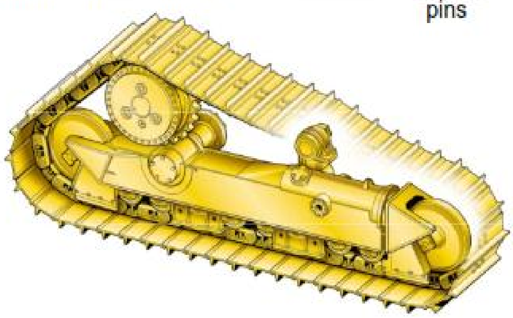
The ripper is the long claw-like device on the back of the bulldozer. Rippers can come as a single shank/giant ripper) or in groups of two or more (multi shank rippers). Usually, a single shank is preferred for heavy ripping. The ripper shank is fitted with a replaceable **tungsten steel alloy** tip.

CRAWLER

Lubricated track link

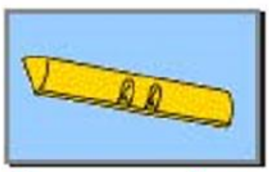






Shoe


Single grouser shoe


Swamp shoe

PRODUCTION FACTORS: BULLDOZERS

1. Soil conditions
2. Angle of swing
3. Bucket fill
4. Fill factor
5. Cycle Time
6. Cycle Time
7. Job efficiency
8. Operator
9. Site condition
10. Equipment conditions

FACTORS INFLUENCING SELECTION OF BLADES

- Type of material to be moved
    1. Particles size and the shape of materials to be moved
        - Rounded particles tend to roll and required a tractor of lesser power than for angular particles
    2. **Voids ratios** of the soil in the bank or undisturbed condition
        - A soil with small voids will be well bonded and difficult to move until the material is loosened
    3. **Moisture content** of the soil greatly affects the pushing forces required
        - Soils with high moisture content levels such as clay tend to be heavy and required large pushing effort

4. Size of machine and the traction capabilities

Blades Rating Bulldozers

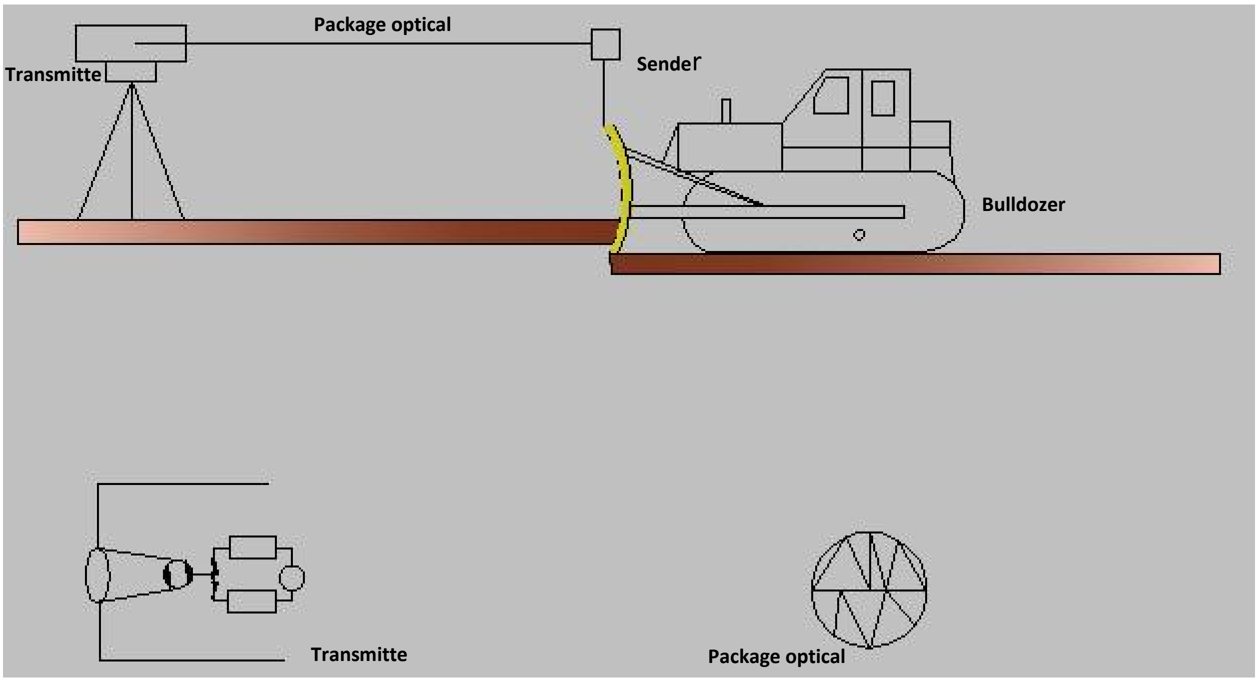
The following method of calculating the capacity of Bulldozer Blades is representative of the method used by most O.E.M. Heavy Equipment Manufacturers. Similar methods are used for Rating Buckets for Hydraulic Excavators and Buckets for Wheel Loaders.

BALLDOZER CAPACITY

Purpose-The purpose of this recommended practice is to provide a uniform method for calculating the capacities of dozer blades. It is intended for relative comparisons of dozer blade capacity, and not for predicting capacities or productivities in actual field conditions. Such determinations would need to consider other parameters, such as efficiency of the blade design, tractor power, tractive effort, soil properties, terrain, operator technique, and duty cycle.

Micro-electronic device

The work could be bulldozed to make the settlement process by micro-electronic device shown in the following figure, by means of a transmitter installed on a bulldozer and a receiver to prove at the end of the project.



Productivity Bulldozer

1. Swelling of the soil as a result of thrills
2. Coefficient of time
3. Operating cycle time per
4. Capacity arms

Mathematical relationships used in the production Bulldozer:

Table (1) shows the correction factor bulge soil for various types of soils

NO.	Soil type	Correction factor Bulge	Mass per cubic meter (kg)
1	Dry clay	0.85	1400
2	Wet clay	0.8	1800
3	Clay	0.83	1600
4	Sandy clay mixed with gravel	0.9	1850
5	Dry sandy	0.89	1950
6	Wet sand	0.88	2150

$$V = \frac{W \,.\, X^{2} \,.®\, .\, H}{360}$$

V = The size of the soil at full load in cubic meters

W = Weight Surface Force Bulldozer

X = 1.5 for Sandy soil and 1.67 for Clay soil

Y = Height Surface Force Bulldozer

Example

What is the production capacity to Bulldoze has the following specifications and works under the following conditions:

Transport distance (M) : 50 meters on the flat land

Weapons off (D): 3 meters wide and 1 meter high

Coefficient time (C) : 50 minutes in an hour

Speed Push (S_P) : 3 km / h

Speed Back (S_B) : 7 km / h

Hard time (H_T) : a half minutes for each session

Solution

From the table (1) Correction factor Bulge equal (0.83)

$$The\ time\ required\ to\ transfer = \frac{50}{3\times\frac{1000}{60}} = \frac{50\times 60}{3\times 1000} = 1\ \min .$$

$$The\ time\ required\ to\ back = \frac{50}{7\times\frac{1000}{60}} = \frac{50\times 60}{7\times 1000} = 0.429\ \min .$$

$$Time\ one\ cycle = 0.5 + 1.0 + 0.429 = 1.929\ \min .$$

$$The\ number\ of\ cycle\ per\ hour = \frac{50}{1.929} = 25.92\ cycle$$

$$V = \frac{W . X^2 .® . H}{360}$$

$$V = \frac{3.(1\times 1.67)^2 .® .33}{360} = 2.4\,m^3$$

$$The\ actual\ size\ of\ the\ soil\ \text{cov}\ erd = 2.4\times 0.83 = 2\ m^3$$

$$\text{Pr}\ oductivity\ Bulldozer = 2\times 25.92 = 51.84\ m^3 / hr .$$

INTERNATIONAL STANDARD FOR BLADE BULLDOZER

1.1 This International Standard specifies a procedure for calculating the volume of dozer blades. It is intended to be used for consistent comparisons of dozer blade capacities presented in commercial literature for tractors, as defined in ISO 6165. It is not to be used for predicting productivity of tractor dozers in actual field conditions or that might be observed in any specific applications. Such determinations need to consider other parameters, such as efficiency of the blade, tractor power, tractive effort, soil properties, terrain, operator technique and duty cycle.

1.2 This International Standard applies to all types of dozers that are mounted on all tractors defined in ISO 6747. This includes straight, angling, semi-U-, and U-blade configurations. It is assumed that the blade face is flat and vertical; the blade included volume is not considered (see figure 1).

2 References

ISO 6165, *Earth-moving machinery — Basic types — Vocabulary.*

ISO 6746-2, *Earth-moving machinery — Definitions of dimensions and symbols — Part 2 : Equipment.*

ISO 6747, *Earth-moving machinery — Tractors — Terminology.*

3 Definitions

For the purposes of this International Standard, the definitions given in ISO 6746-2 and the following apply.

3.1 Straight blade dozers

3.1.1 blade projected area, A_m : Blade area, in square metres, exclusive of the end bit extensions, projected on a vertical plane parallel to the middle part of the cutting edge of the blade (see figure 2). The blade is located in the mid-pitch position with the cutting edge on the ground reference plane (GRP).

3.1.2 blade width, W : Distance, in metres, from outside to outside of the blade, exclusive of the end bits (see figure 3).

3.1.3 effective blade height, H' : Vertical height, in metres, that with W width, produces a projected area equal to A_m : i.e. $H' = A_m / W$ (see figure 3).

3.1.4 effective blade contour : Simplified representation of the blade face for calculating the blade capacity based on the vertical plane bounded by W and H' (see figure 3).

3.2 Semi-U- and U-blade dozers

3.2.1 blade projected area, A_m : (Identical to that for a straight blade — see 3.1.1.)

3.2.2 blade width, W : (Identical to that for a straight blade — see 3.1.2.)

3.2.3 effective blade height, H' : (Identical to that for a straight blade — see 3.1.3.)

3.2.4 effective blade contour : Simplified representation of the blade face for calculating the blade capacity. It is established by intersecting planes extending vertically from the cutting edge at the GRP, with the blade in the mid-pitch position. The frontal dimensions are W and H' (see figure 4).

3.2.5 wing angle, α : Angle, in degrees, measured at the cutting edge on the GRP with the blade in the mid-pitch position. This angle describes the orientation of the intersecting planes that establish the effective blade contour (see figure 4).

3.2.6 wing length, Z : Length, in metres, of the wing measured parallel to the blade width (see figure 4).

3.3 Angling blade dozers in straight position

3.3.1 blade width, W : Blade width, in metres (see figure 5).

3.3.2 effective blade height, H' : Vertical height, in metres, with the blade in the mid-pitch position (see figure 5).

3.3.3 effective blade contour : Simplified representation of the blade face for calculating the blade capacity based on the vertical plane bounded by W and H' (see figure 5).

4 Volume symbols and formulae

4.1 Symbols

V_s : Volume of straight, angling, semi-U- and U-blades using the simplified representation of the blade face for calculating the blade capacity shown in figures 3 and 4.

V_u : Volume of the contour of semi-U- and U-blades, taking into account the wing angle and wing length (see figure 6).

V_1 : Capacity volume of straight and angling blades.

V_2 : Capacity volume of semi-U- and U-blades.

4.2 Capacity volume formulae

As shown in figure 6, the following formulae will indicate blade capacities, in each case in cubic metres.

4.2.1 Straight and angling blade capacity

$$V_1 = V_s$$

$$V_s = 0,8\ W\,(H')^2$$

4.2.2 Semi-U- and U-blade capacity

$$V_2 = V_s + V_u$$

$$V_s = 0,8\ W\,(H')^2$$

$$V_u = Z\,H'\,(W-Z)\tan\alpha$$

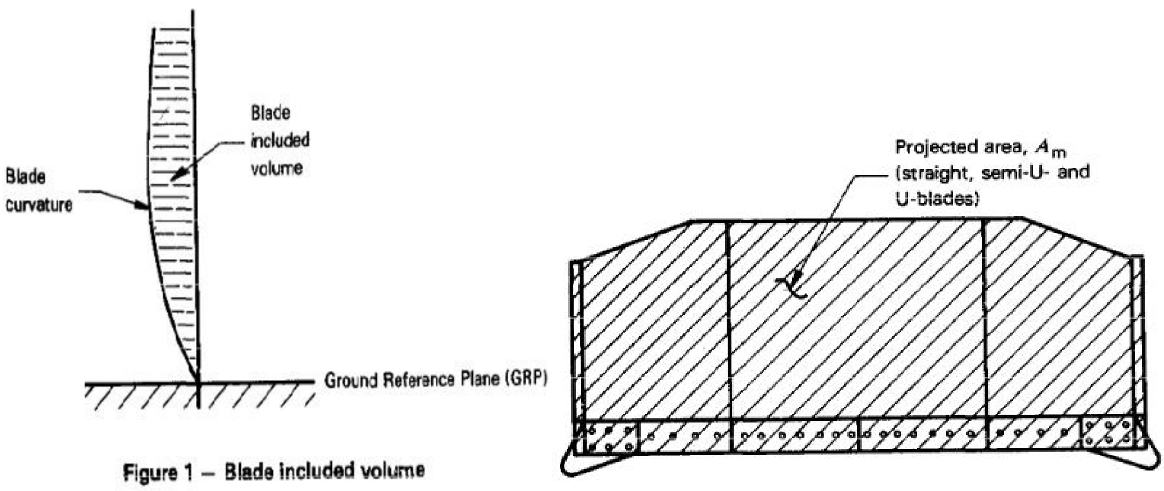


Figure 1 — Blade included volume

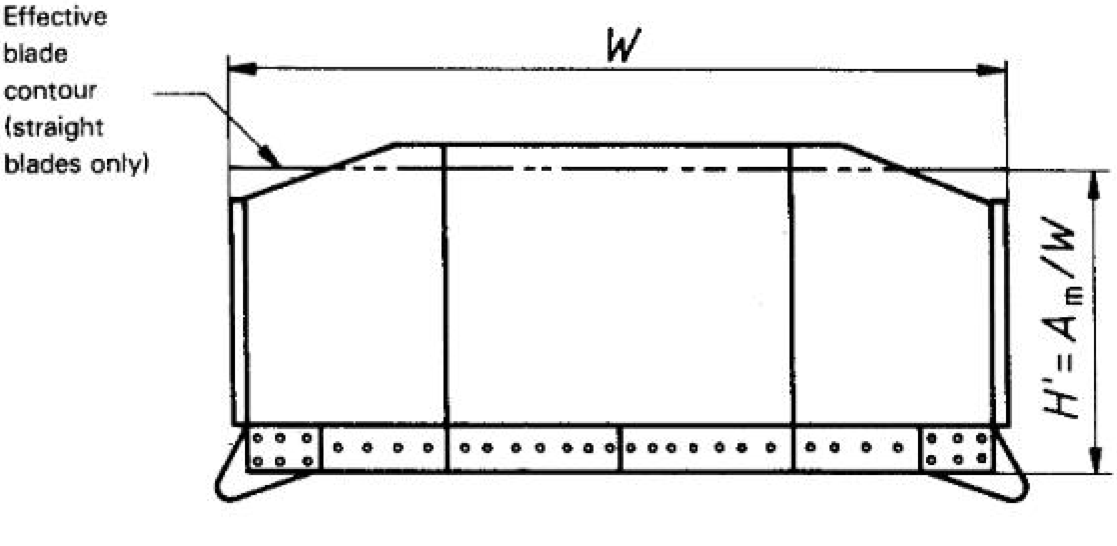


Figure 3 — Straight, semi-U-, U-blade dimensions

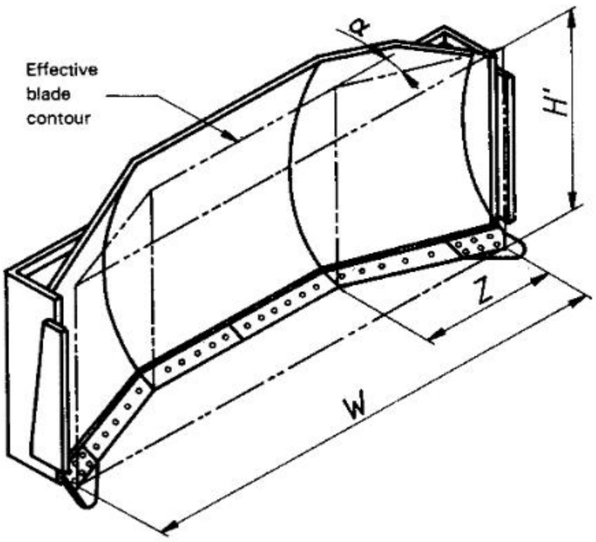


Figure 4 — Effective blade contour of semi-U- and U-blades

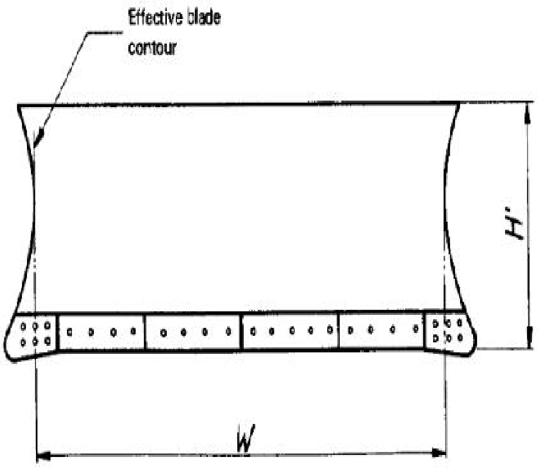


Figure 5 – Angling blade dimensions

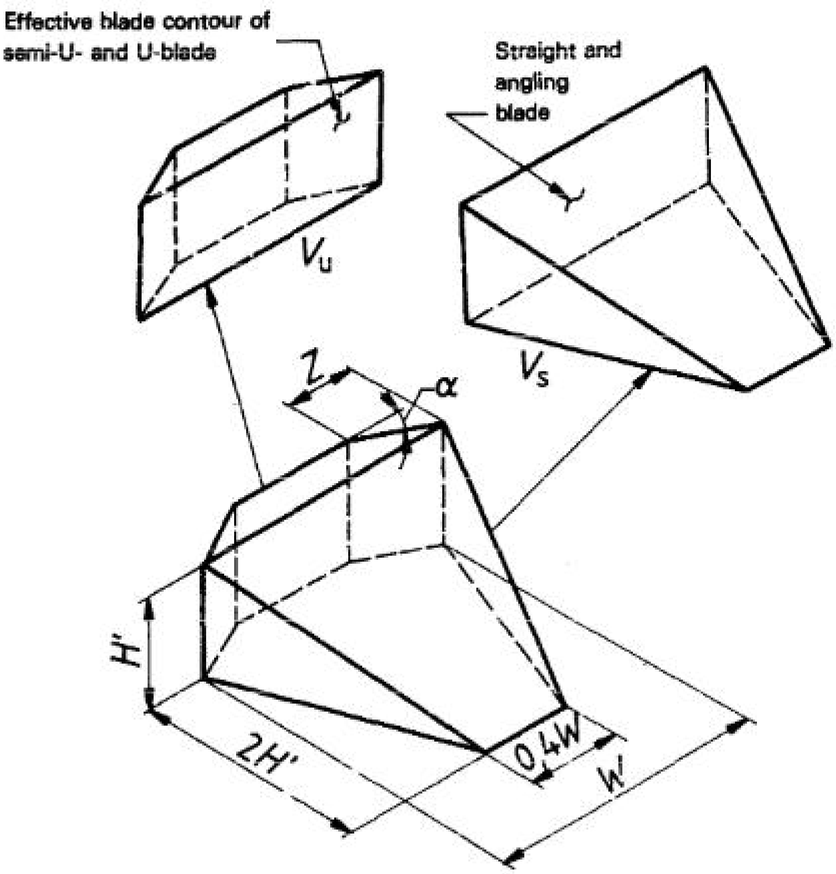


Figure 6 — Blade volume

Capacity formulas

1. Straight and Angling Blade Capacity:

$$V = V_S = 0.8 \times W \times H'^2 \;\; unit(m^3)$$

2. Semi-U and U-Blade Capacity:

$$V = V_S + Vu$$
$$V_S = 0.8 \times W \times H'^2$$
$$Vu = Z \times H' \times (W - Z)\tan\alpha$$

$W = Blade\ width$; $Z = Wing\ length$; $\alpha = wing\ angle$

$H' = Effective\ Blade\ height$; $V = Volume(Capacity\ in\ m^3)$

Example 1 : find Straight and Angling Blade Capacity if Blade width equal (2.9 m) and Effective blade height equal (1.55 m) ?

Solution

W = 2.9 m ; H’ = 1.55 m

$$V = V_S = 0.8 \times W \times H'^2 \;\; unit(m^3)$$
$$V = 0.8 \times 2.9 \times 1.55^2 = 5.57 M^3$$

Example 2 : find Semi-U Blade Capacity if Blade width equal (6.321 m) , Effective blade height equal (2.179 m) and angle blade equal (30°) ?

Solution

W = 6.321 m ; H' = 2.179 m ; α = 30° ; Z = 0.4 W

$$V = V_S + Vu$$
$$V_S = 0.8 \times W \times H'^2$$
$$Vu = Z \times H' \times (W - Z)\tan\alpha$$

$$V_S = 0.8 \times W \times H'^2 = 0.8 \times 6.321 \times 2.179^2 = 24.01 m^3$$

$$Z = 0.4W = 0.4 \times 6.321 = 2.528\ m$$

$$Vu = Z \times H' \times (W - Z) \tan \sim$$

$$V_u = 2.528 \times 2.179 \times (6.321 - 2.528) \times \tan 30 \circ$$

$$= 5.509 \times 3.793 \times 0.577 = 12.057\, m_3$$

$$V = V_S + V_u = 24.01 + 12.057 = 36.067\, m^3$$

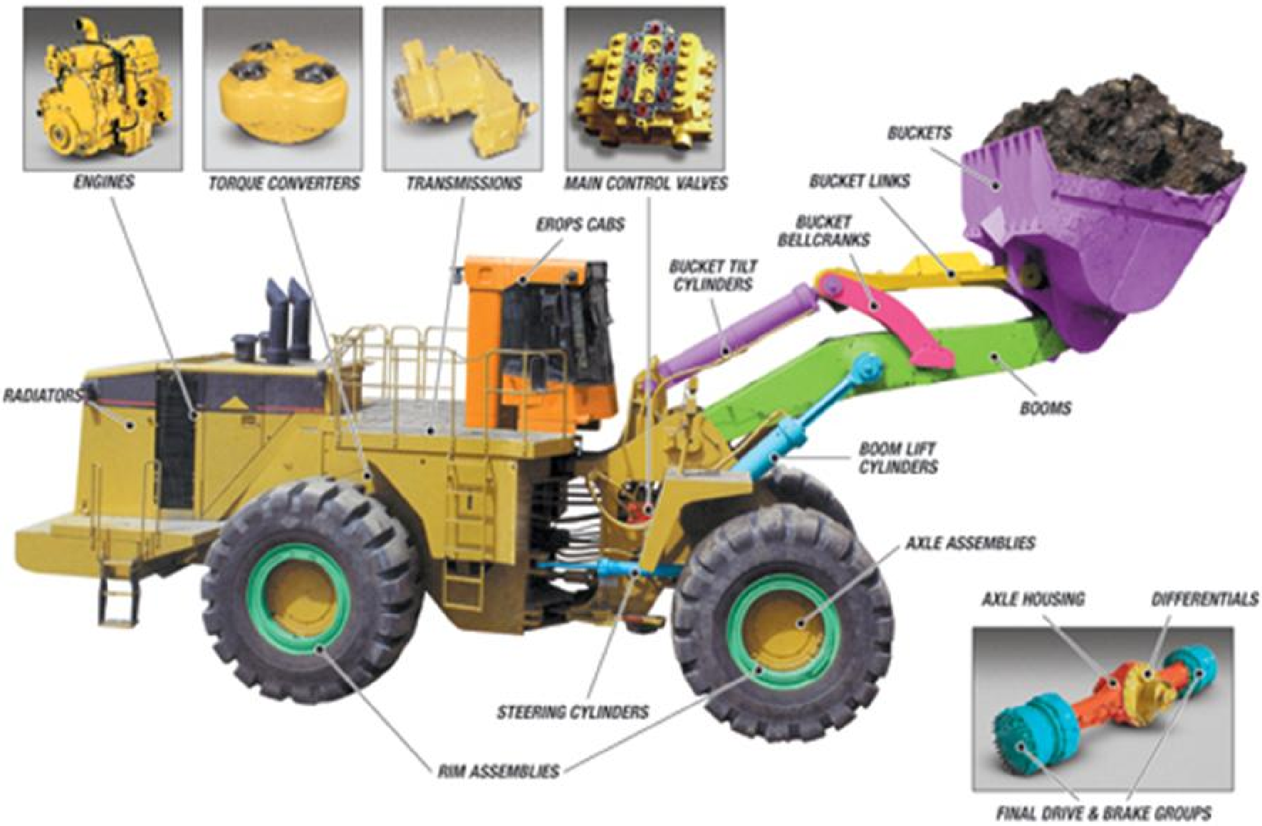
Example 3 : find U Blade Capacity **Caterpillar D4G XL Bulldozer if Dimensions: Blade** The blade width is 2671 mm (XL), 2921 mm (intermediate), 3146 mm (LGP). The height is 1028 mm (XL), 922 mm (intermediate) and 922 mm (LPG) ?

LOADERS

A loader is one machine in common use to pick up excavated material.

It consists of a crawler or wheeled tractor with a shovel or a bucket mounted in front.

Components of Shovel



A shovel is also known as a front-end loader, loader, a bucket loader or sometimes a scoop loader. it is a bucket that is on the end of movable arms. it tilts and is used to lift and move material. the shovel is part of a tractor. it is either a permanent-mounted version or a removable attachment. the bucket at the end of the arms can be replaced with other tools, such as forks for lifting pallets or bale tools that are specifically designed to handle bales of hay.

Shovels are used for:

1. digging operations
2. levelling operations
3. pushing operations
4. load and carry operations
5. handling loads similar to crane
6. mounting other equipment and acting as a tool carrier
7. preparing and levelling stock storage pads
8. towing loads and other equipment similar to a tractor
9. general clean-up of work areas

there are many makes and models of shovels. You must locate the operator's manual for your shovel and study the operating and safety features. You will find that the position and operation of the controls vary considerably.

Before starting or operating your shovel:

1. locate and identify each control and familiarize yourself with its function .

2. check the position and operation of park brakes and emergency devices .

3. know how to stop the engine .

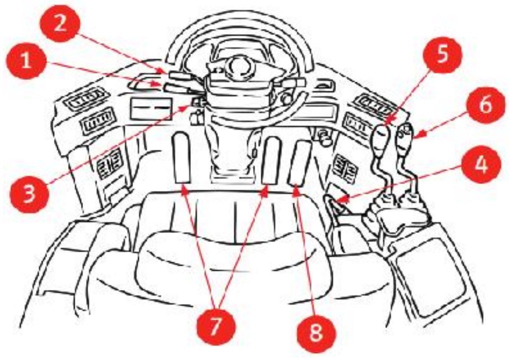
Some shovels are tracked machines. the tracks allow them access to rougher working areas that would damage tires.

Larger shovels have a steering feature known as articulated steering. they steer from a pivot point set between the front and rear axles. this allows the front axle to be solid and support more weight. the driver can steer the loaded bucket in a tight arch to reach a truck. there is danger of tipping over, because the weight is shifted away from the body of the shovel.

Shovel controls

there are a number of pedals and levers to operate. Various combinations will be used at the same time, depending on what work you will be doing. Check the operator's manual for your shovel for details of position and operation.

Typical controls

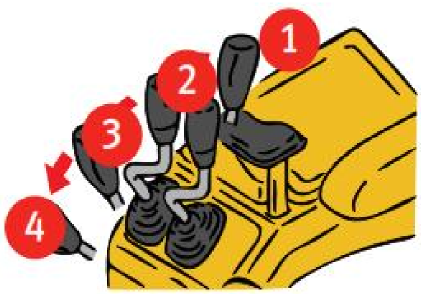


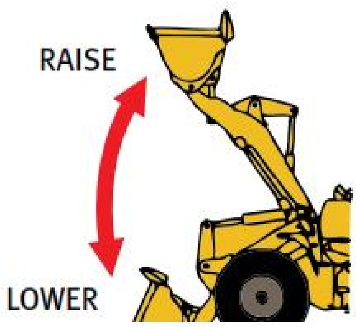
1. transmission gear selection lever
2. forward and reverse shift lever
3. Park brake switch
4. Safety lock lever
5. Bucket control lever
6. Lift control lever with transmission kick down switch
7. Brake pedals
8. Accelerator.

As well as the control levers and pedals, shovels have alarms and gauges to help you check the condition of the shovel.
Alarms let you know when the shovel is not operating properly or when there is a danger.

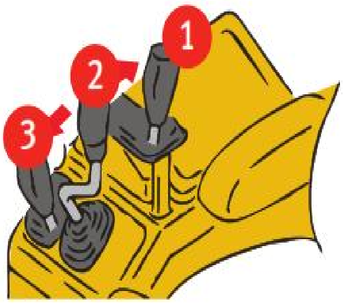
Bucket Controls

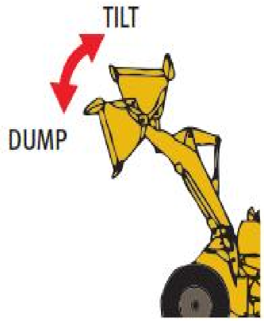
The controls to lift the bucket are: 1. Raise 2. Hold 3. Lower 4. Float





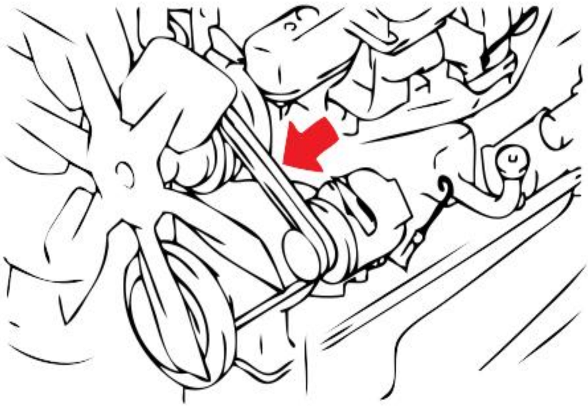
The controls to tip the bucket are: 1. Roll back, crowd or tilt 2. Hold 3. tip or dump

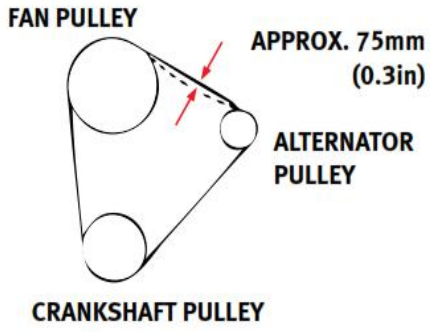




Fan Belts

You will need to check the tension of the belt by depressing between the fan and the alternator pulleys.



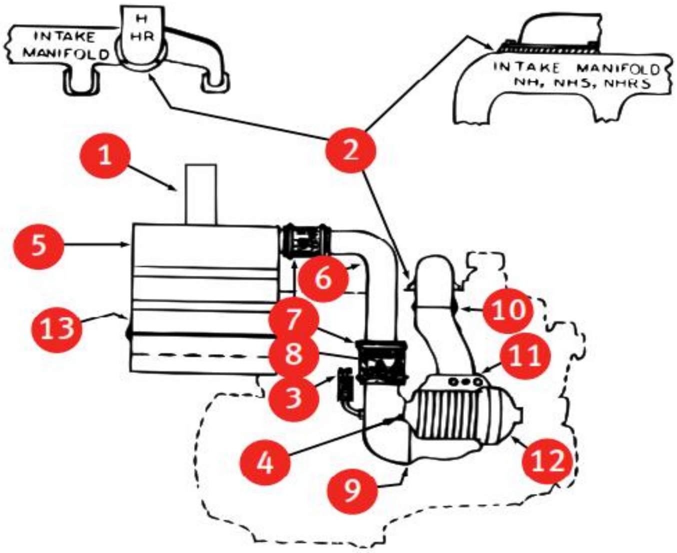


Air Filters and Air Intake

Air cleaner systems also need regular maintenance. the most common sign that the air cleaner system needs attention is that the indicator will change color or the gauge will show into the red, or an alarm could sound, depending on the system. Check for clogging of the air cleaner. Check all tubing, hoses and clamps for security and sealing. Check your operator manual for the air cleaner warning system on your shovel. Some air cleaner elements can be cleaned and reused and some will need replacing.

1. Raw air intake area
2. intake manifold pressure seal
3. Air cleaner restriction indicator

4. Low pressure (super charger) manifold
5. Air cleaner
6. Clean air tube
7. Hump hose clamps
8. Hump hoses
9. Supercharger intake seal
10. trunking support bracket
11. High pressure air seal
12. Super charger



5

Lubrication and Hydraulic Systems

Check for leaks and have any leaks repaired. Check around the engine, all hydraulic cylinders and hoses, under the shovel engine, transmission and oil cooler. Adjust levels to manufacturer's specifications, if needed. Check the operator's manual for your shovel for details of lubrication that is required before each use.

Fuel System

fuel levels may be checked by fuel gauge, dip stick, sight gauge or mobile warning device.

Before removing the fuel cap, clean dirt and dust from around the filler to prevent contamination.

Add fuel through an acceptable fuel filter to the required level. Replace the filler cap when finished.

equipment should be refueled after use to cool the remaining fuel and minimize the intake of moisture from atmosphere
overnight.

Check the breather on the fuel tank. A blocked breather may cause a vacuum in the fuel tank and reduce or stop fuel flow. Clean
the breather at regular intervals.

Oil Levels - Engine Sump

ensure that the shovel is on level ground and allow engine to cool.

1. Remove the dipstick and wipe clean with a cloth.
2. Replace the dipstick fully into the hole.
3. Remove the dipstick and check the oil level.
4. Add oil to the correct level if found to be insufficient. Make sure that the oil is of the correct type.

Hydraulic Oil Level Reservoir

1. oil level may be checked by dipstick or sight gauge.
2. if checking by dipstick, use the same method as checking for engine sump oil levels.
3. Add oil to the correct level if found to be insufficient. Make sure that the oil is of the correct type.

Engine Coolant Level

if the engine has been running, remove the radiator cap with caution to avoid serious burns.

Modern engines use recovery cooling systems. this system has a small external container or bottle attached to the radiator overflow tube which stores coolant. this is forced out during operation due to expansion.

Some of the contents of the recovery bottle are drawn back into the radiator as the engine cools after shut-down.

Questions

Q1 Name four typical controls on a shovel.

Q2 Name five operations shovels are used for.

Q3 What should you do before inspecting underneath a bucket?

Q4 What are alarms on a shovel used for?

Q5 Large shovels have special steering that lets the driver steer a loaded bucket in a tight arch to reach a truck. What is it called?

GRADERS

Graders are multipurpose machines used primarily for general construction and maintenance of roads and runways, moving large amounts of materials laterally by side casting. Additionally, the grader can be used for crowning and leveling roads, mixing and spreading materials, ditching and bank sloping, blade mixing asphalt materials, snow removal, and scarifying. The grader is a rubber-tired hydraulically operated, for all grader functions. The steering system, moldboard, and scarifier are hydraulically controlled. Although the grader, at times, must be hauled to and from jobsites, the grader has an advantage over other heavy equipment because of its capability to travel over the road under its own power.

NOTE: When hauling a grader with a tractor- trailer, ensure the height of the grader cab clears all overhead obstacles. A variety of makes and models of graders are used in the NCF. Each operator is responsible for reading the operator's manual to obtain detailed information about each make and model. *Capacities range from a blade width of 2.50 to 7.30 m and engines from 93–373 kW (125–500 hp). Certain graders can operate multiple attachments, or be used for separate tasks like underground mining.*

Graders are multipurpose machines used for:

1. Finishing
2. Shaping bank
3. Sloping
4. ditching

*A grader's primary purpose is **cutting** and **moving** with the **moldboard**.*

Graders can work on slopes as steep as 3:1.

Graders and Grading options

There are two general types of graders:

• **motor graders:** they run on their own power source. They require only one operator and no external equipment. They are expensive; and

• **towed grader**: they are towed by an external power source, usually by a tractor.

They require one additional operator.

In addition, manual labourers may also be used to create correct shape and camber for a road. The labourers will require a number of hand tools including shovels and rakes.

Grader availability in the region

There are many motor graders available in the region. Medium sized motor graders (between 120-180 HP) are the most common in the three countries. The most common model is the CAT 120H. Large motor graders (greater than 180 HP) are also available but they are not as common as the medium sized ones. The general consensus among the contractors in the region is that they are not appropriate for works on rural roads. This is due to their large weight and wide turning circle. Small graders or compact graders (less than 120HP) are not common in the study countries.

A typical small motor grader model, produced in the US, is the LeeBoy 635. The table below provides information of different motor grader types. Motor graders are costly equipment. The purchase price of a new motor grader ranges from US$ 60.000 to 160.000 .

Comparison with Bulldozers

A grader can move small amounts of material but cannot perform bulldozer-type work because of the structural strength and location of its moldboard.

Important Components of Grader

The components of the grader that actually do the work of finishing are:

1. **Moldboard (Blade)**
2. **Scarifer**

Graders may also be equipped with light rear-mounted **rippers**.

GRADER COMPONENTS

The basic grader consists of a prime mover and a grader mechanism. The principal parts of a grader are — single-engine unit. The single engine provides power shown in figure.

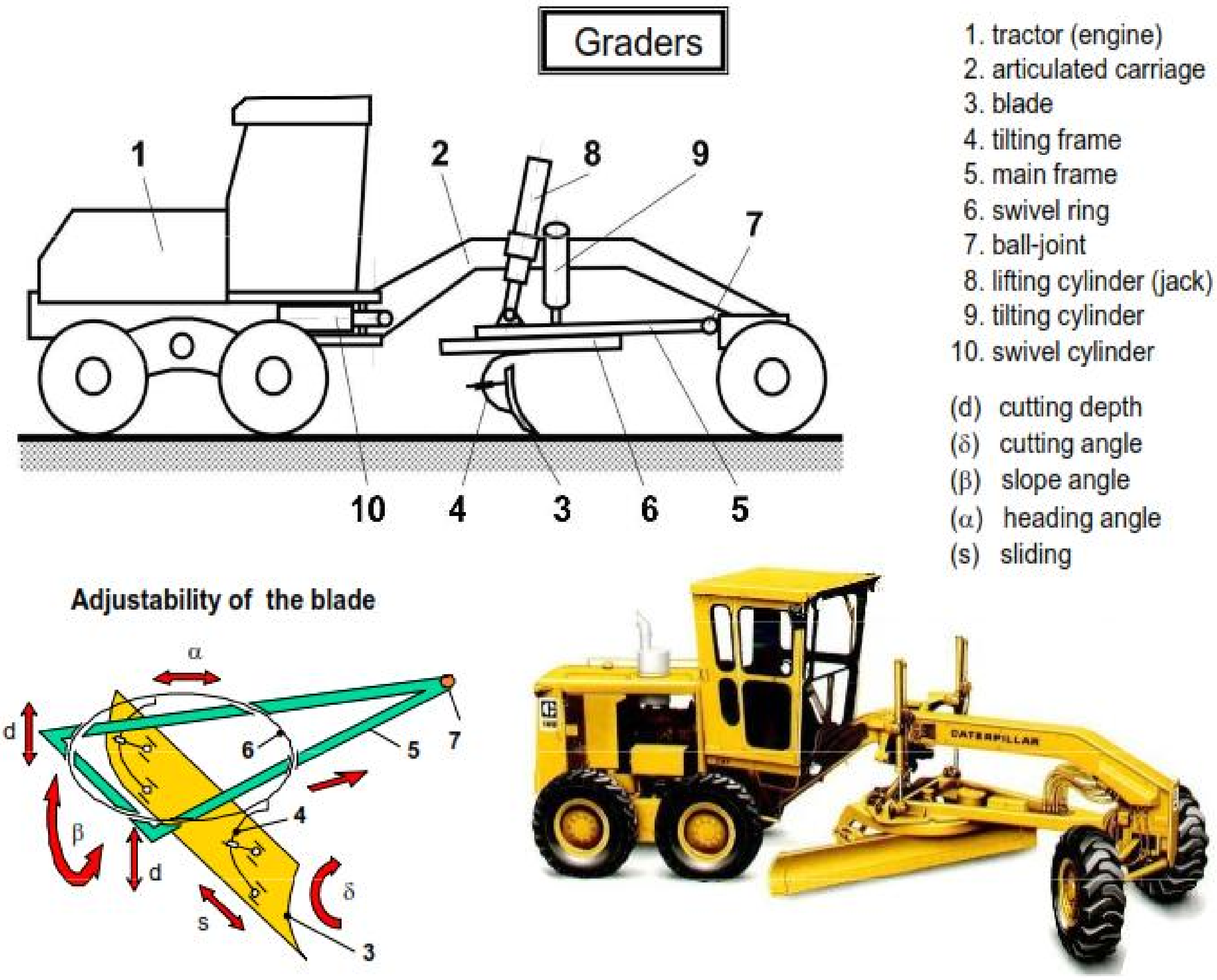


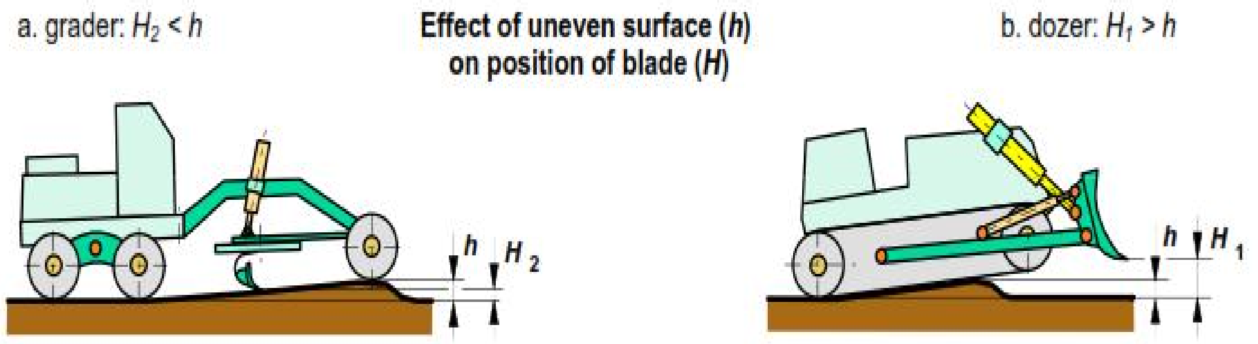
Figure - Principal parts of a motor grader.

Grader : Multi-purpose equipment used for:

1. Finishing
2. Shaping
3. Bank sloping

4. Ditching
5. Mixing
6. Spreading
7. Side casting
8. Leveling and crowning
9. Site striping operations
10. Earth road maintenance

Typical application: refinery earthworks, levelling, topsoil excavation, spreading



Laser controlled (C) grader equipped with ripper (A) and front blade (B) attachment

Estimating Production

Estimate grading 4 miles of dirt road using a CAT 120H.

Ditching 6 passes 1st gear

Reshaping 9 passes 2nd gear

Final grading 4 passes 3rd gear

The following formula is used to estimate the total time :

$$Total \quad time \; = \frac{P \times D}{S \times E}$$

P = number of passes required

D = distance traveled in each pass, in miles or feet

S = speed of grader (mph or fps)

E = grader efficiency factor

FORMULA FOR DISTANCES IN MILES

$$Time \; = \frac{NO. \; Passes \; \times dist \; ance}{speed \; \times efficiency}$$

• Distance in miles

• Speed in miles per hour

• Time will be in hours

STEP 1. NUMBER OF PASSES

Ditching 6 passes

Reshaping 9 passes

Final grading 4 passes

STEP 2. DISTANCE

Grading 4 miles

STEP 3. SPEED

CAT 120H

1st gear	**2.3 mph**
2nd gear	**3.1 mph**
3rd gear	**4.5 mph**

STEP 4. EFFICIENCY FACTOR

For an average operator during daylight hours would expect a

50 min-hour efficiency

or an 0.83 efficiency factor

STEP 5.

1. TIME TO DITCH

STEP 1 : Number of passes = 6

STEP 2 : Distance = 4 miles

STEP 3 : Speed = 2.3 mph

STEP 4 : Efficiency factor = 0.83

$$Time_{DITCH} = \frac{6 \times 10}{2.3 \times 8.3} \Rightarrow \frac{24}{1.91} = 12.6 \ hr$$

2.TIME TO RESHAPE

STEP 1 : Number of passes = 9

STEP 2 : Distance = 4 miles

STEP 3 : Speed = 3.1 mph

STEP 4 : Efficiency factor = 0.83

$$Time_{RESHAPE} = \frac{9 \times 4}{3.1 \times 0.83} \Rightarrow \frac{36}{2.57} = 14.0 \ hr$$

3.FINAL GRADING

STEP 1 : Number of passes = 4

STEP 2 : Distance = 4 miles

STEP 3 : Speed = 4.5 mph

STEP 4 : Efficiency factor = 0.83

$$Time_{FINAL \ GRADER} = \frac{4 \times 4}{4.5 \times 0.83} \Rightarrow \frac{16}{3.74} = 4.3 \ hr$$

4.TOTAL TIME

Time to ditch	12.6 hr
Time to reshape	14.0 hr
Final grading	4.3 hr
Total time	**30.9 hr**

NOTE : FORMULA FOR DISTANCES IN FEET

$$Time = \frac{NO.\ Passes \times distance}{88 \times speed \times efficiency}$$

• Distance in feet

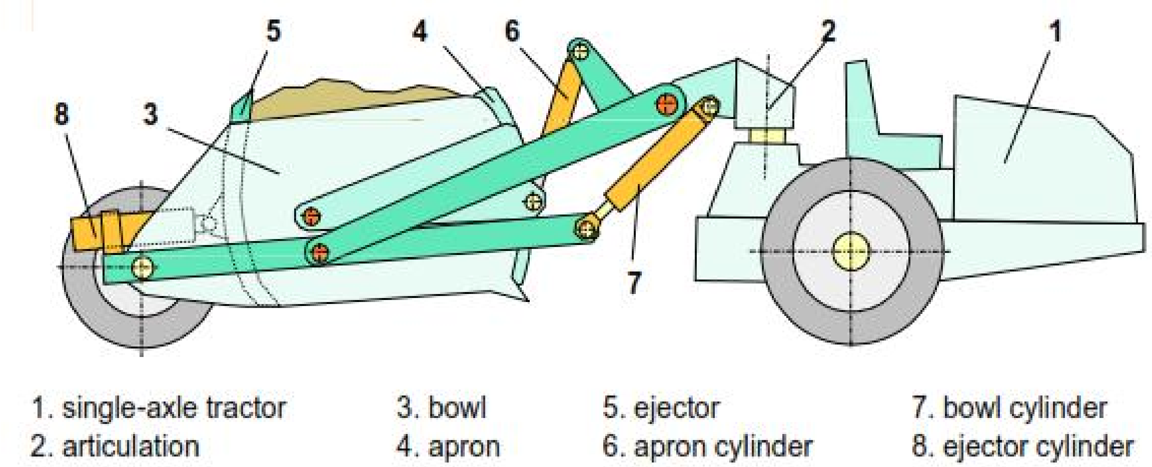
• Speed in miles per hour

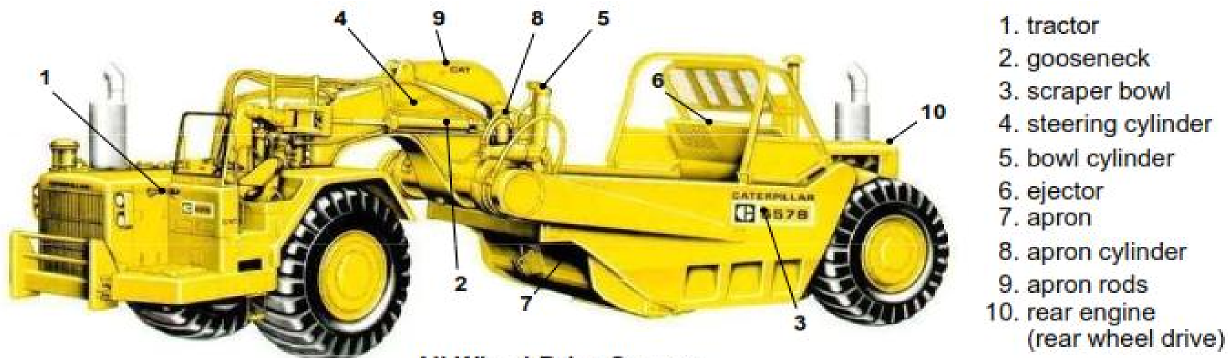
• Time will be in minutes

SCRAPERS

The design of scrapers (tractor scrapers) allows for loading, hauling, dumping, and spreading of loose materials. Use a scraper for medium-haul earthmoving operations and for moving ripped materials and shot rock. The haul distance (zone of operation), the load volume, and the type and grade of surface traveled on are the primary factors in determining whether to use a scraper on a particular job. The optimum haul distance for small- and medium-size scrapers is 3,000 feet or less.

Scraper compounded





All-Wheel-Drive Scraper
(Charging and penetration provided by towing power of tractor)

Elevator-scraper

MOVING MACHINE – SCRAPERS

1. The piece of plants consist of a power unit and a scraper bowl
2. used to excavate and transport soil where surface stripping, site levelling, light clearing, rough and fine grading, bank sloping, ditching/channel and cut and fill activities
3. Particularly for large volumes
4. Produce a very smooth and accurate formation level

Three basic types:-

1. Crawler-drawn scraper
2. Two-axle scraper
3. Three-axle scraper

CRAWLER-DRAWN SCRAPER

1. Has truck and gooseneck arrangement
2. Consist of four-wheeled scraper bowl towed behind a crawler power unit
3. Hauling speed - less than 8 km/h
4. Scraping speed – less than 3 km/h

Wheel scraper

Is an integrated self-propelled unit

a. **Two-axle**
    i. have two wheeled power unit has advantages over its four wheeled power unit or three axle due to its manoeuvrable
    ii. Offers less rolling resistance and has better traction since the engine is mounted closer to the driving wheels

b. **Three-axle**
    i. Advantages of being able to use its top speed more frequently, generally easier to control and power unit can be used for other activities which is not possible with most two-axle

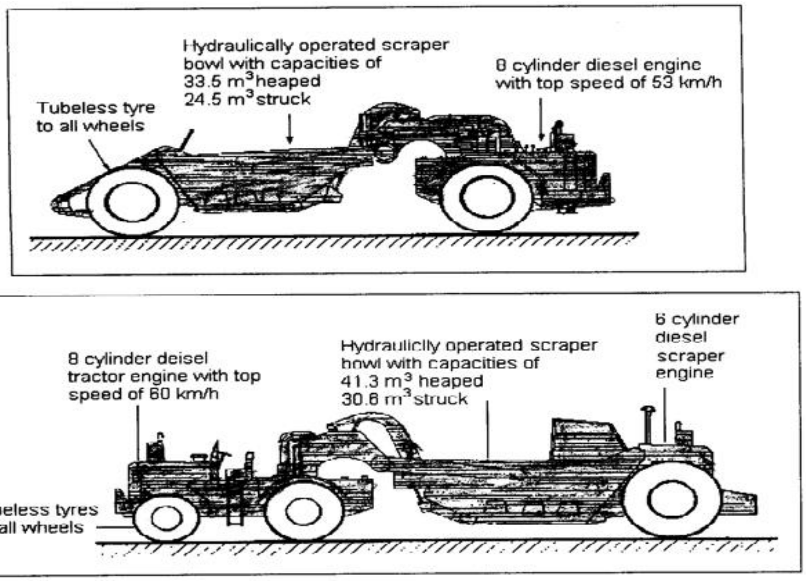
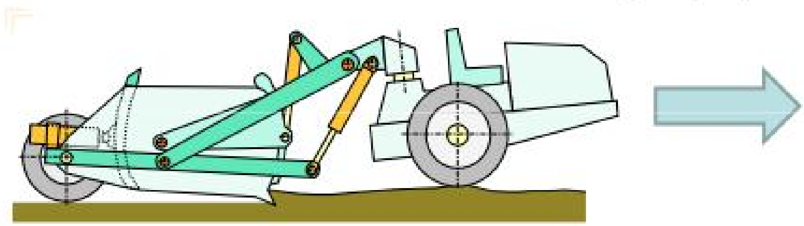
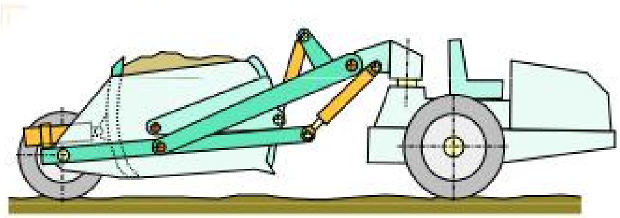


Figure- typical 2 and 3 axial scraper

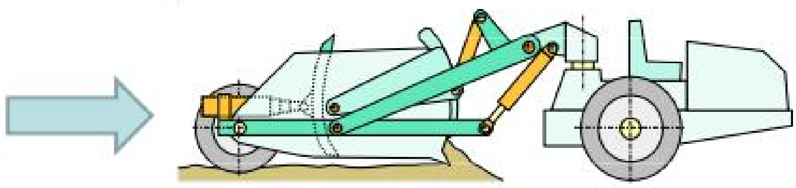
Phases of a cycle (turn)



Excavating (charging): apron up (open), bowl down (penetrating into the soil)



Hauling (and compacting): apron down (close), bowl up



Discharging (spreading and compacting): apron up (open), bowl up, ejector forward

Loading of scrapers

- Scrapers are loaded by the

following methods:-

1. Self-loading in loose soils
2. Push loaded by crawler tractor

3. Elevating self-loading
4. Push pull
5. Top loaded by hydraulic excavator or front end loader

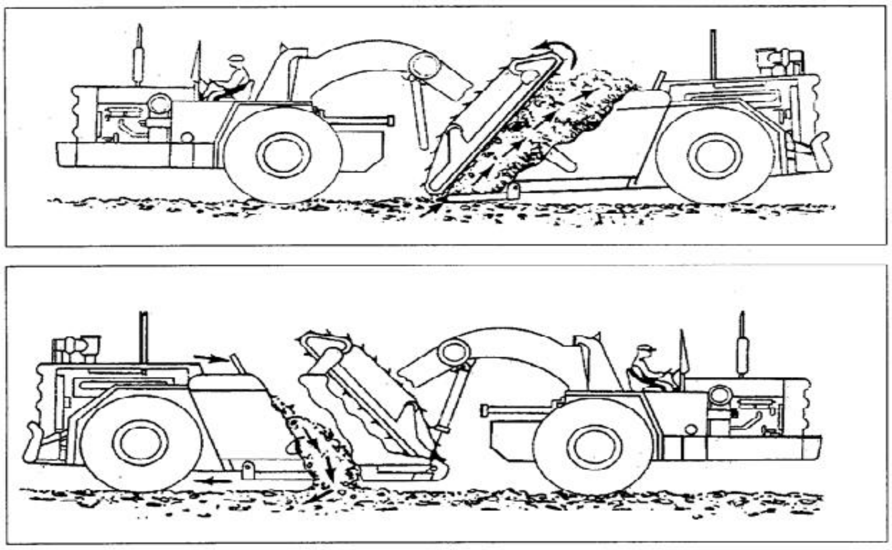


Figure- Typical Elevating Scraper

Scraper cutting blade

a. Standard Blade – used for fine grading and finishing and for general earthmoving operations where the soils are not too stiff or hard
b. Drop Centre Blade – Operates in broad range of soil and for stripping grass and root bound soils. The centre section is dropped so as to prevents the dam up of the materials inside the bowl when loading and unloading.
c. Double Drop Centre Blade – Used in heavy clay or where the material has a tendency to loosed in sheets.
d. Drop Centre Tooth Mounted Blade – operates efficiently on material which are hard or crusty.

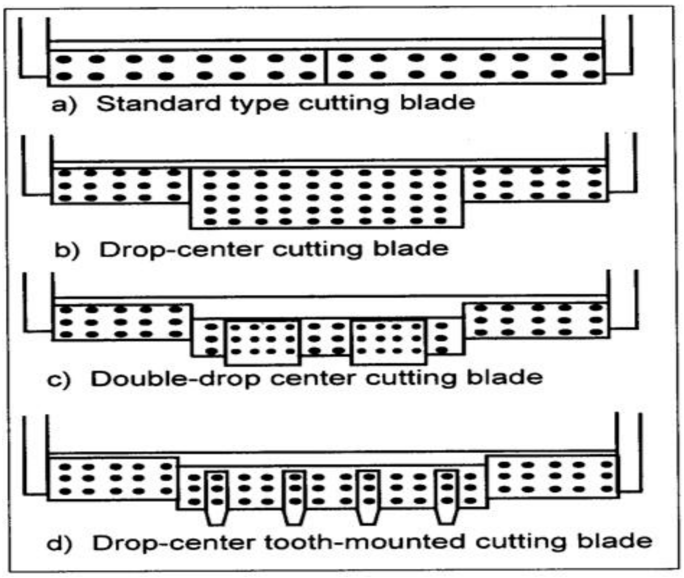


Figure – Cutting blade for Scraper

The basic operating parts of a scraper are these:

• **Bowl.** The bowl is the loading and carrying component. It has a cutting edge, which extends across the front bottom edge. Lower the bowl until the cutting edge enters the ground for loading, raise it for carrying, and lower it to the desired lift thickness for dumping and spreading.

• **Apron.** The apron is the front wall of the bowl. It is independent of the bowl and, when raised, it provides an opening for loading and spreading. Lower the apron during hauling to prevent spillage.

• **Ejector.** The ejector is the rear wall of the bowl. Keep the ejector in the rear position when loading and hauling materials. Activate the ejector to move forward during spreading to provide positive discharge of materials.

OPERATING RANGE

The optimum haul distance for the small- and medium-size scrapers is 300 to 3,000 feet. There are larger scrapers that are effective up to 5,000 feet.

SELECTION

A scraper is a compromise between a machine designed exclusively for either loading or hauling. For medium-distance movement of material, a scraper is better than a Bulldozer because of its travel-speed advantage and it is better than a truck because of its fast load time, typically less than a minute. Another advantage of the scraper is that it can spread its own load and quickly complete the dump cycle.

PRODUCTION CYCLE

The production cycle for a scraper consists of six operations—loading, haul travel, dumping and spreading, turning at the dump site, return travel, and turning and positioning to load. *Figure* shows the functions of the apron, bowl, and ejector during loading, hauling, and dumping.

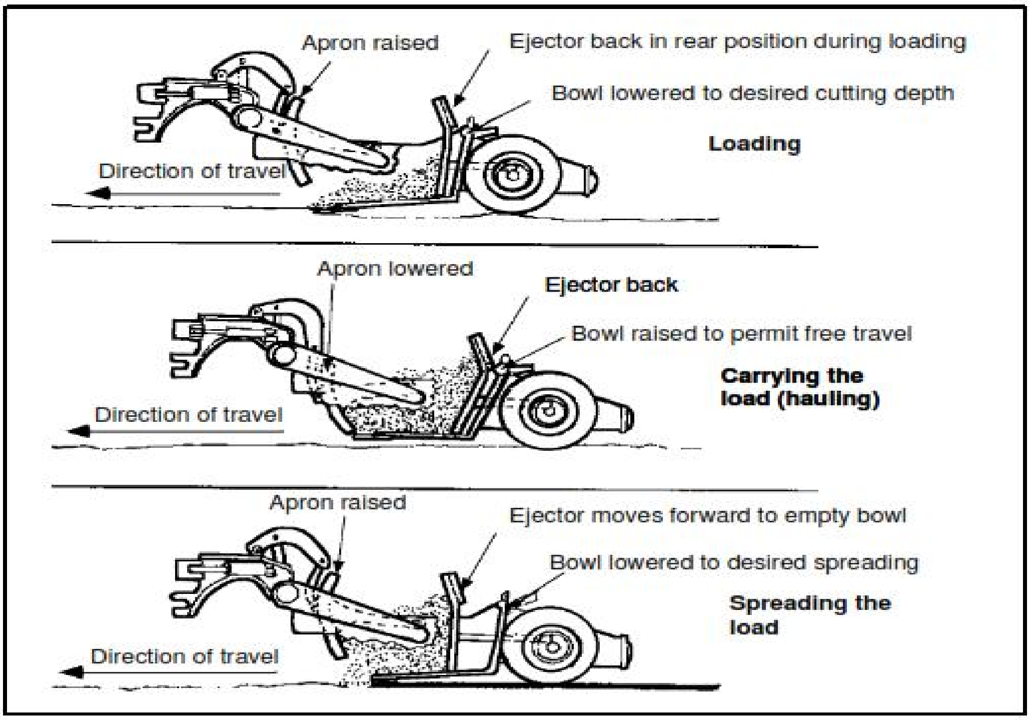


Figure - Functions of the Apron, Bowl, and Ejector

Types of scrapers

1. Push-Loaded: Single Powered Axle

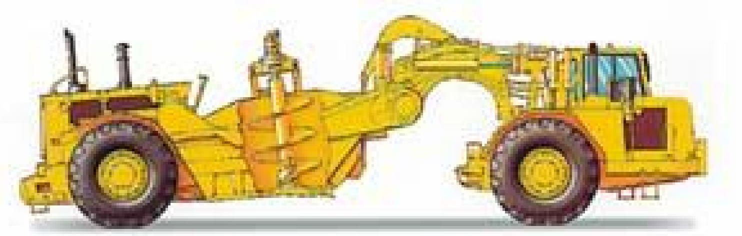
Problem

The estimated cycle time for a wheeled scraper is 6.5 min.

Calculate the number of pushers required to serve a fleet of nine scrapers using pushers.

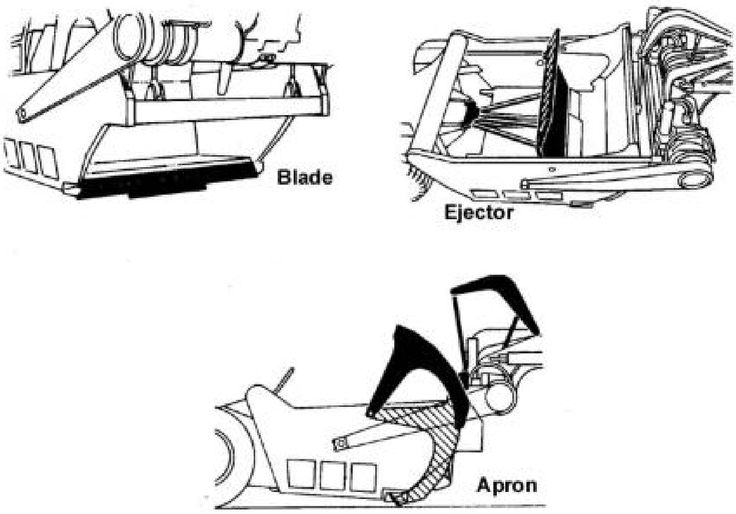
Determine the result for both backtrack and chain loading methods.

2. Push-Pull: Tandem- Powered Axle



Elevating

The ejector is a curved plate located at the back of the bucket. The ejector can be moved forwards to push material out of the bowl. Figure highlights the blade, apron, and ejector on a typical scraper bowl.



Parts of Scraper Bowl

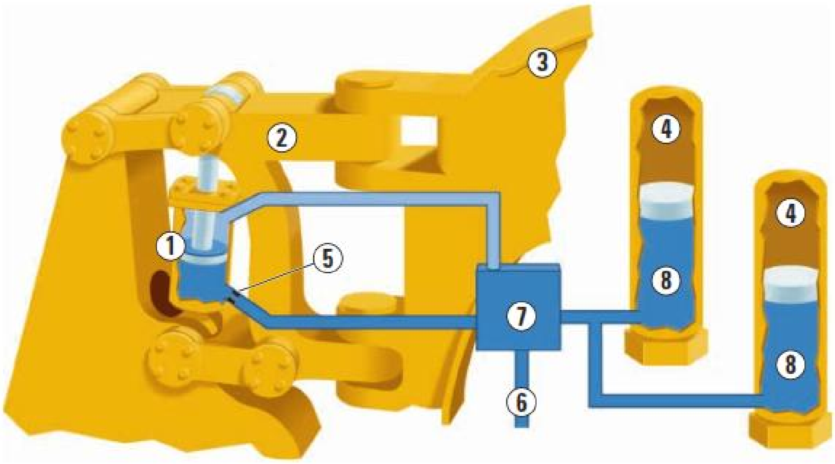
mph (45 km/h) while carrying a full load. This makes them economical, because they can move a large volume of soil over a considerable distance at a relatively high speed. The disadvantage to equipping scrapers with rubber tires is that they cannot generate the traction necessary to work on soft soils or to load themselves to capacity. Therefore, all scrapers are designed to have some type of assistance in loading. Scrapers are classified by their method of loading. Scrapers are either push-loaded, push-pull, or elevating.

Structures

Superior structural design and construction optimize performance and reliability.

1. Load cylinder
2. Hitch castings
3. Scraper gooseneck
4. Nitrogen accumulators
5. Orifice
6. Oil from tractor hydraulic system

7. Leveling valve
8. Free floating pistons



Scraper Manufacturers. The following is a partial list of companies in the United States that manufacture scrapers. This list is for reference only. Inclusion or omission of a manufacturer from this list does not imply endorsement by the Department.

NO.	Manufacturer	Location
1	Caterpillar	Peoria, IL
2	Terex	Tulsa, OK

PRODUCTION ESTIMATES

3-73. Following is an explanation of production estimating based on a step-by step method using the CAT 621B scraper. When developing data for production estimates, consider all factors that influence production. Consider the scraper's weight, the weight of the load, and the average grade and rolling resistance of both the haul and return routes in arriving at a cycle time. The same steps are applicable to other makes and models of scrapers, using the appropriate tables and charts for those scrapers.

Step 1. Determine the vehicle weight, empty and loaded.

• **Empty vehicle weight (EVW), in tons.** Using *Table 3-1*, first determine the EVW from the EVW column based on the specific make and model of the scraper.

• **Weight of load, in tons.** Determine the weight of the load in pounds by determining the scraper load volume in cubic yards (this is in LCY of the material) and the material unit weight (in pounds per LCY). If no specific material-weight data is available, use the information in *Table 1-2, page 1-4,* as an estimate. Multiply the scraper load volume by the unit weight in pounds per LCY of the material to be excavated. Then, convert the resulting weight into tons by dividing the amount
by 2,000.

$$\text{Weight of load (pounds)} = \text{scraper load volume (LCY)} \times \text{material unit weight (pounds per LCY)}$$

$$\text{Weight of load (tons)} = \frac{\text{weight of load (pounds)}}{2,000}$$

Table. Scraper Specifications

Make and Model	Heaped Capacity (Cubic Yards)	EVW (Tons)
CAT 613B	11	15.6
CAT 621B	20	33.3

• **Loaded or gross vehicle weight (GVW).** Determine the GVW by adding the EVW (tons) and the weight of load (tons).

GVW (tons) = EVW (tons) + weight of load (tons)

Example 1

Determine the GVW of a CAT 621B single-powered scraper with a 20 LCY load of dry loam.

From Table 1-2, dry loam is 1,900 to 2,200 pounds per LCY. Use an average value of 2,050 pounds per LCY.

$$\text{Weight of load (tons)} = \frac{20 \text{ LCY} \times 2{,}050 \text{ pounds per LCY}}{2{,}000 \text{ pounds per ton}} = 20.5 \text{ tons}$$

$$\text{EVW} = 33.3 \text{ tons}$$

$$\text{GVW} = 33.3 \text{ tons} + 20.5 \text{ tons} = 53.8 \text{ tons}$$

Step 2. Determine the average grade (in percent) and the distance (in feet) for both the haul and return routes.

Uphill grades are positive (+) and downhill grades are negative (-). Obtain this information from a mass diagram or a haul route profile

EXAMPLE 2

The project mass diagram indicates that there is a 5 percent downhill grade from cut to fill and that the one-way distance is 800 feet. The same route will be used for both the haul and the return.

Haul:

Average grade = -5 percent

Distance = 800 feet

Return:

Average grade = +5 percent

Distance = 800 feet

Step 3. Determine the rolling resistance (in pounds). Rolling resistance is the force resisting the movement of a vehicle on level ground. This is primarily caused by the tires penetrating the road's surface, the tires flexing, and internal gear friction . Express the rolling resistance for a given road surface in pounds per ton of vehicle weight. Gives some representative rolling-resistance values for various types of road surfaces. If the expected tire penetration is known, determine the rolling resistance for

the haul and the return using the following formulas

$$RR_{Haul} = (40 + [30 \times TP]) \times GVW$$

$$RR_{Return} = (40 + [30 \times TP]) \times EVW$$

where—

$\mathbf{RR_{Haul}}$ = haul rolling resistance, in pounds

$\mathbf{RR_{Return}}$ = return rolling resistance, in pounds

40 = constant that represents the flexing of the driving mechanism, in pounds per ton

30 = constant that represents the force required to climb out of the rut, in pounds per ton per inch

TP = tire penetration, in inches (may be different for the haul and the return)

EXAMPLE 3

Determine the rolling resistance (haul and return) for a CAT 621B scraper carrying a 20.5-ton load if the tire penetration during the haul is 3 inches and the tire penetration on the return is 1 inch.

$$RR_{Haul} = (40 + [30 \times 3 \text{ inches}]) \times 53.8 \text{ tons} = 6{,}994 \text{ pounds}$$

$$RR_{Return} = (40 + [30 \times 1 \text{ inch}]) \times 33.3 \text{ tons} = 2{,}331 \text{ pounds}$$

Rolling Resistance

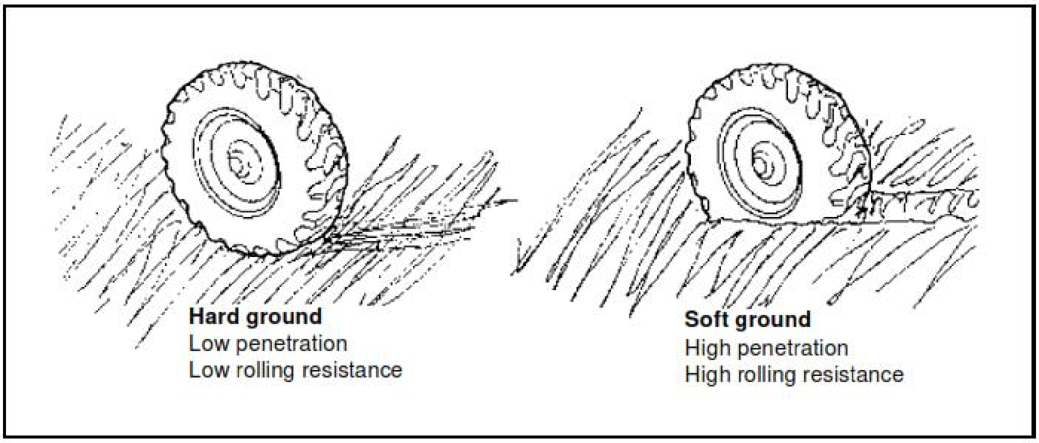


Figure- Shown Rolling Resistance

Table. Representative Rolling-Resistance Values

Road Condition	Resistance Value (Pounds Per Ton)
Hard, smooth surface with no tire penetration (well maintained)	40
Firm, smooth surface, flexing slightly under load (well maintained)	65
Flexible dirt roadway (irregular surface): With about 1 inch of tire penetration With up to 4 inches of tire penetration	 100 150
Soft, muddy roadway (irregular surface or sand) with over 6 inches of tire penetration	220 to 400

Step 5. Determine the total time in hours required to complete the mission. To determine the total time required to complete a mission, the total volume to move, the hourly production rate, and the number of scrapers to be used on the job must be known.

$$\text{Total time (hours)} = \frac{Q}{P \times N}$$

where—

Q = total volume to move, in BCY

P = hourly production rate, in BCY per hour

N = number of scrapers

<u>EXAMPLE 4</u>

Determine how many hours it would take to move 19,440 BCY, using three CAT 621B scrapers, each with an hourly production rate of 296 BCY per hour.

$$\text{Total time (hours)} = \frac{19,440}{296 \text{ BCY per hour} \times 3} = 22 \text{ hours}$$

EXAMPLE 5

A scraper with an estimated payload of 34,020 kg (75,000 lb) is operating on a total effective grade of 10%. Find the available rimpull and maximum attainable speed.

$$\text{Empty weight} + \text{payload} = \text{Gross weight}$$

$$43{,}945 \text{ kg} + 34{,}020 \text{ kg} = 77{,}965 \text{ kg}$$

$$(96{,}880 \text{ lb} + 75{,}000 \text{ lb} = 171{,}880 \text{ lb})$$

Solution. Using Fig. 3.6, read from 77,965 kg (171,880 lb) on top of the gross weight scale down (line B) to the intersection of the 10% total resistance line (point *C*).

Go across horizontally from *C* to the Rimpull Scale on the left (point *D*). This gives the required rimpull: 7593 kg (16,740 lb).

Where the line *CD* cuts the speed curve, read down vertically (point *E*) to obtain the maximum speed attainable for the 10% effective grade: 13.3 km/h (8.3 mph).

The vehicle will climb the 10% effective grade at a maximum speed of 13.3 km/h (8.3 mph) in fourth gear. Available rimpull is 7593 kg (16,740 lb).

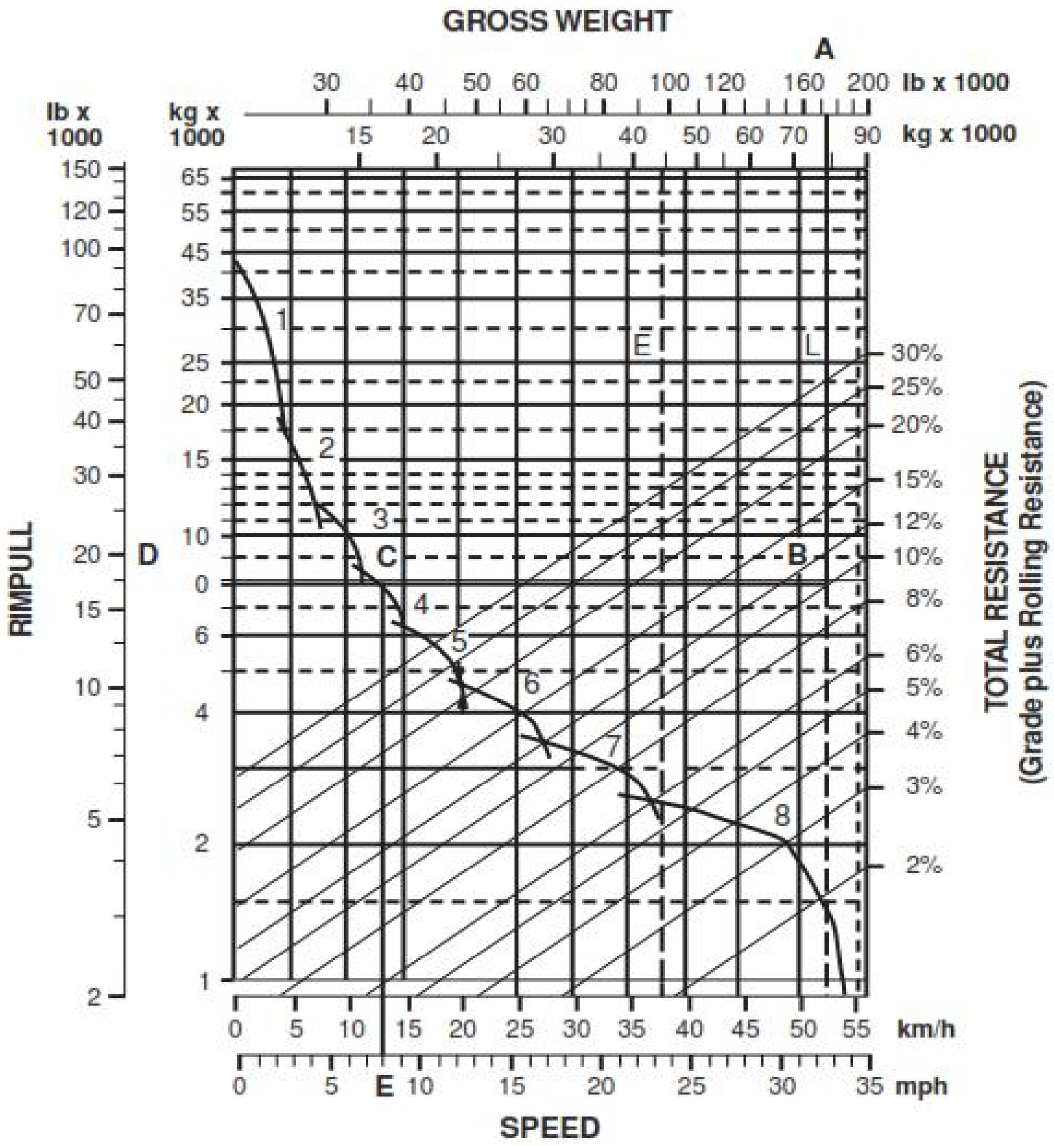
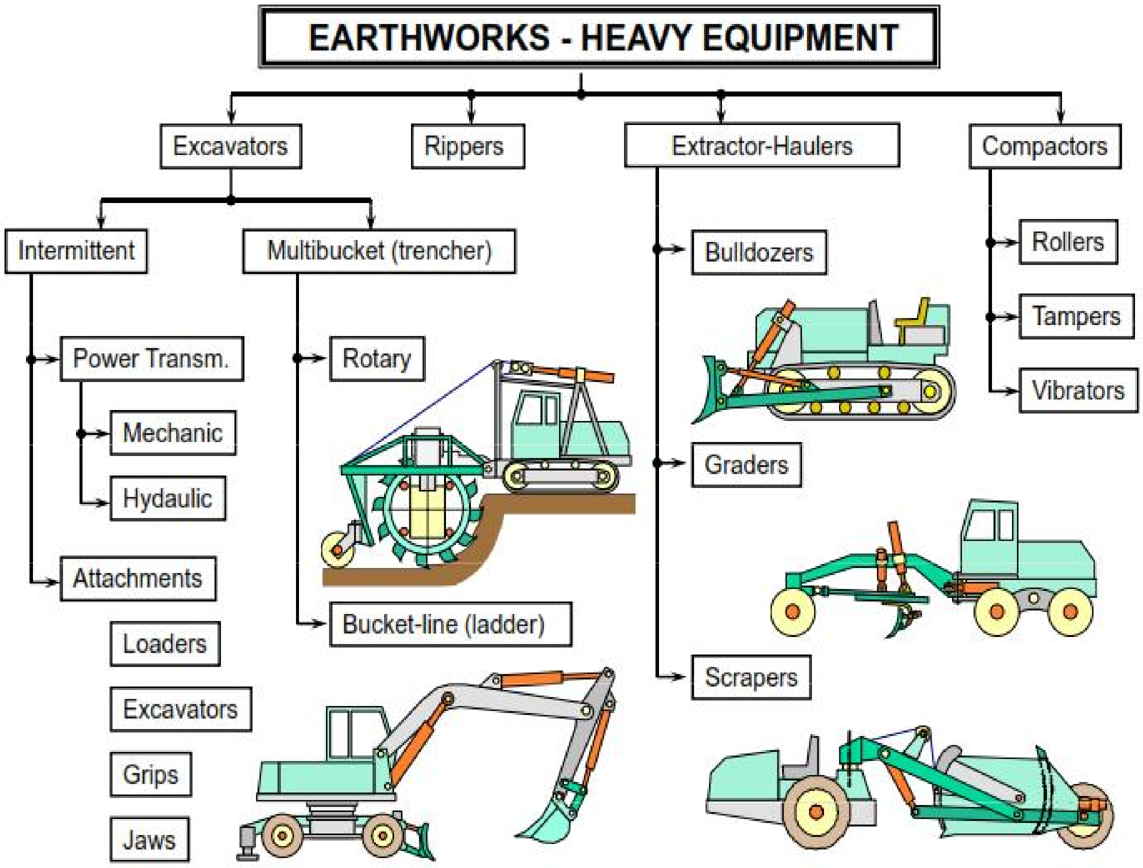


FIGURE Rimpull-speed-gradeability curves. (*Source: Caterpillar Performance Handbook*, 24th ed., 1993. Caterpillar, Peoria, IL.)

EXCAVATOR



Excavators are heavy construction equipment consisting of a boom, stick, bucket and cab on a rotating platform (known as the "house"). The house sits atop an undercarriage with tracks or wheels. A cable-operated excavator uses winches and steel ropes to accomplish the movements. They are a natural progression from the steam shovels and often called power shovels. All movement and functions of a hydraulic excavator are accomplished through the use of hydraulic fluid, with hydraulic cylinders and hydraulic motors. Due to the linear actuation of hydraulic cylinders, their mode of operation is fundamentally different from cable-operated excavators

Excavators are also called **diggers**, **JCBs** (a proprietary name, in an example of a generic trademark), **mechanical shovels**, or **360-degree excavators** (sometimes abbreviated simply to **360**).

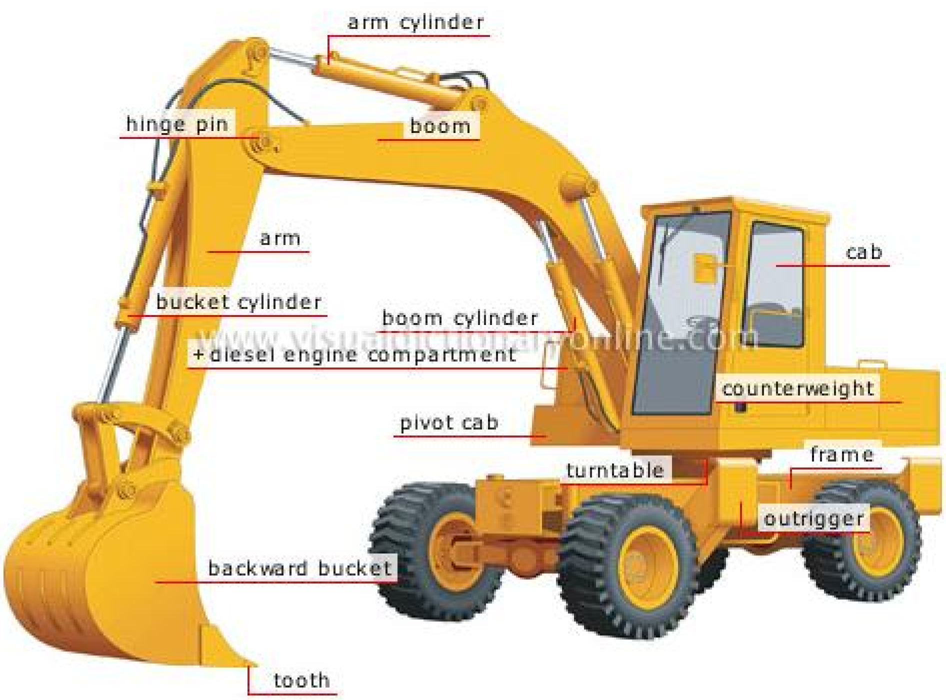
Usage

Excavators are used in many ways:

- Digging of trenches, holes, foundations
- Material handling
- Brush cutting with hydraulic attachments
- Forestry work
- Forestry mulching
- Demolition
- General grading/landscaping
- Heavy lift, e.g. lifting and placing of pipes
- Mining, especially, but not only open-pit mining
- River dredging
- Driving piles, in conjunction with a pile driver

Excavators compounded

Machine made up of a pivot cab with a bucket attached for moving various types of material.



Modern, hydraulic excavators come in a wide variety of sizes. The smaller ones are called mini or compact excavators. For example, Caterpillar's smallest mini-excavator weighs 2,060 pounds (930 kg) and has 13 hp; their largest model is the largest excavator available (a record previously held by the Orenstein & Koppel RH400) the CAT 6090, it weighs in excess of 2,160,510 pounds (979,990 kg), has 4500 h.p and has a bucket size of around 52.0 m³ depending on bucket fitted.

Engines in hydraulic excavators usually just drive hydraulic pumps; there are usually 3 pumps: the two main pumps are for supplying oil at high pressure (up to 5000 psi) for the arms, swing motor, track motors, and accessories, and the third is a lower pressure (700 psi) pump for Pilot Control, this circuit used for the control of the spool valves, this allows for a reduced effort required when operating the controls.

The two main sections of an excavator are the undercarriage and the house. The undercarriage includes the blade (if fitted), tracks, track frame, and final drives, which have a hydraulic and gearing providing the drive to the individual tracks, and the house includes the operator cab, counterweight, engine, fuel and hydraulic oil tanks. The house attaches to the undercarriage by way of a center pin. High pressure oil is supplied to the tracks' hydraulic motors through a hydraulic swivel at the axis of the pin, allowing the machine to slew 360° unhindered.

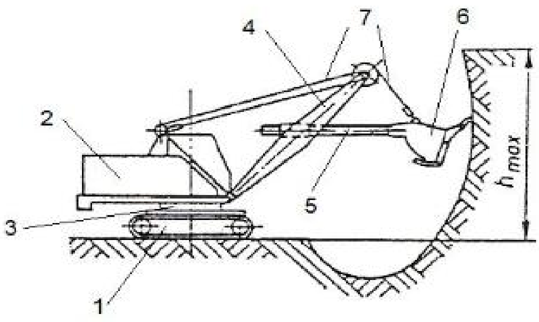
The main boom attaches to the house, and can be one of several different configurations:

1. Most are mono booms: these have no movement apart from straight up and down.
2. Some others have a knuckle boom which can also move left and right in line with the machine.

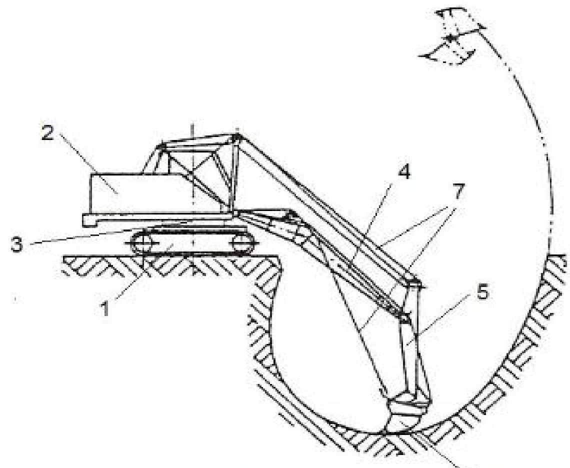
3. Another option is a hinge at the base of the boom allowing it to hydraulically pivot up to 180° independent to the house; however, this is generally available only to compact excavators.

4. There are also triple-articulated booms (TAB).

Cable-operated excavators



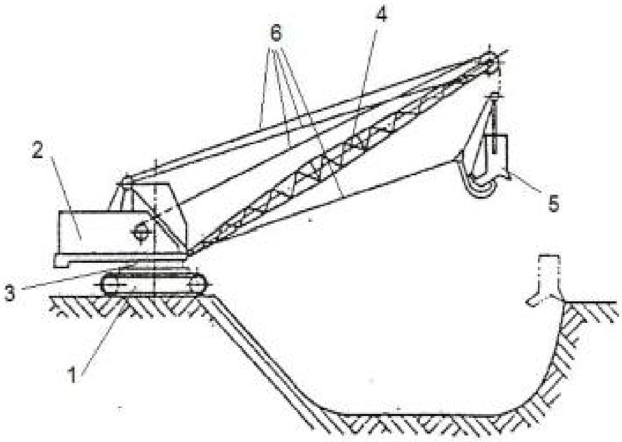
Front shovel



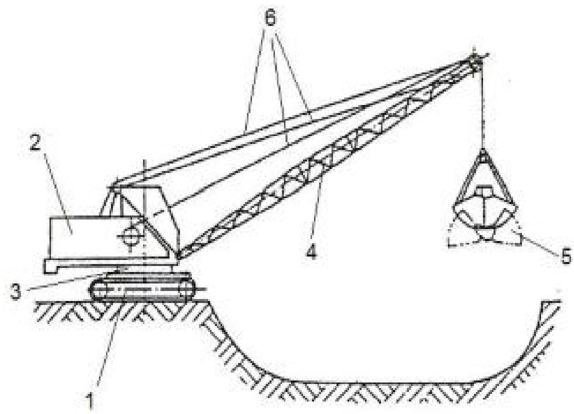
Backacter

1. bogie undercarriage
2. slewing upper machinery (drive, operator's canopy, counter-weight)
3. turn mechanism
4. boom
5. arm
6. bucket
7. cable-lines

Features:
• complicated driving system
• many moving elements → manifold potential failures
• low working performance
• extensive maintenance requirements



Dragline

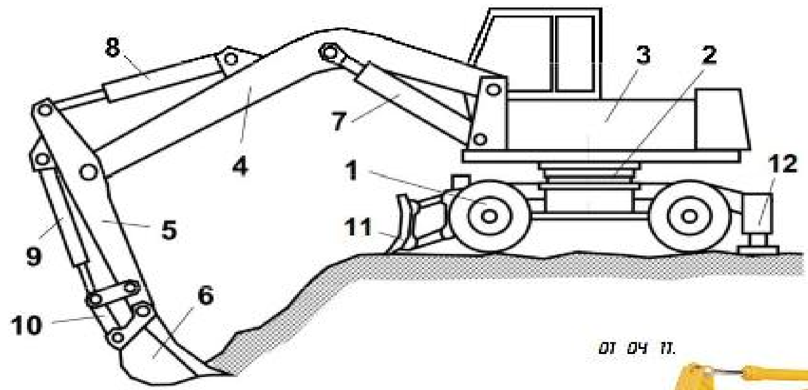


Clamshell

1. bogie undercarriage
2. slewing upper machinery (drive, operator's canopy, counter-weight)
3. turn mechanism
4. boom
5. bucket
6. cable-lines

Features:
• complicated driving system
• many moving elements → manifold potential failures
• low working performance
• extensive maintenance requirements

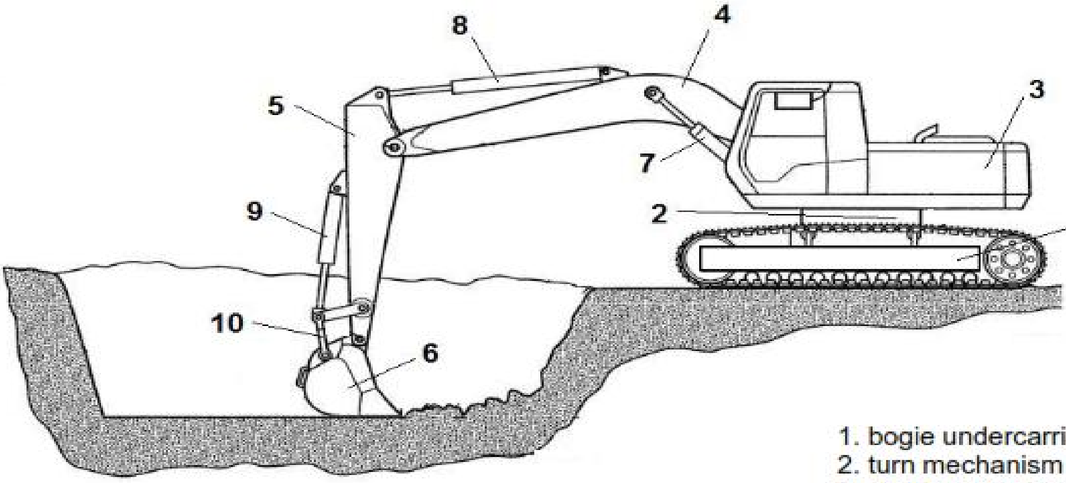
Hydraulic excavators
(slewing excavators)



1. wheel-bogie
2. turn mechanism
3. slewing upper machinery
4. boom
5. arm
6. backacter
7. boom cylinders
8. arm cylinder
9. bucket cylinder
10. bucket moving rods
11. auxiliary attachment
12. outrigger

Wheel-mounted backacter slewing excavator

Hydraulic excavators
(slewing excavators)

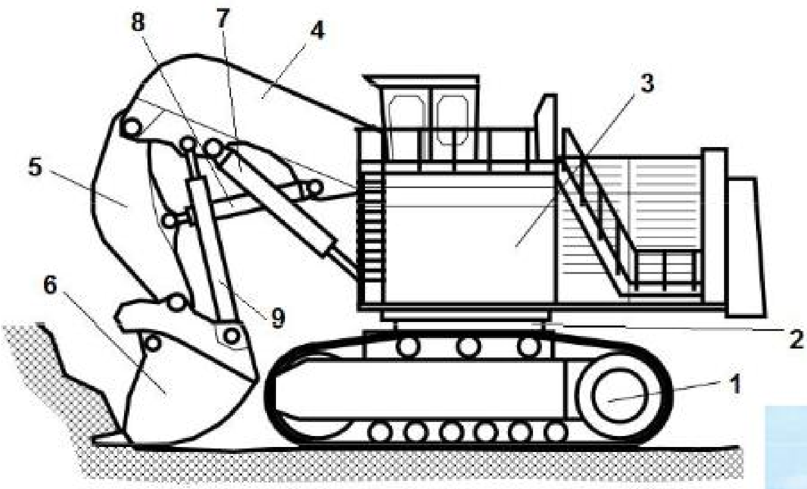


Track-mounted backacter slewing excavator

1. bogie undercarriage
2. turn mechanism
3. slewing upper machinery
4. boom
5. arm
6. backacter
7. boom cylinders
8. arm cylinder
9. busket cylinder
10. Bucket moving rods

Hydraulic excavators
(slewing excavators)

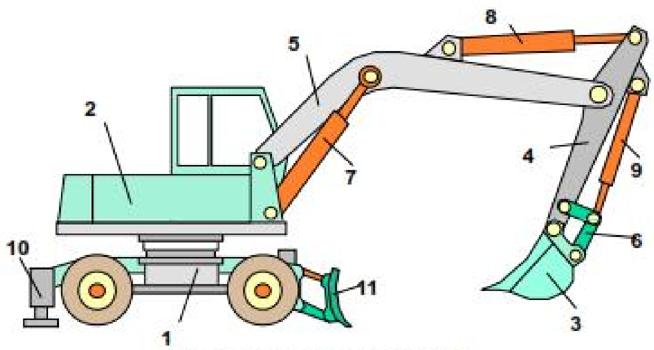
1. bogie undercarriage
2. turn mechanism
3. slewing upper machinery
4. boom
5. arm
6. front shovel
7. boom cylinders
8. arm cylinder
9. shovel moving cylinders



Track-mounted front shovel slewing excavator

Hydraulic excavators
(slewing excavators)

1. frame (carriage)
2. slewing upper machinery (engine, operator's canopy, counter-weight)
3. hoe (showel or bucket)
4. arm
5. boom (monoblock or articulated)
6. hoe rods
7. boom lifting cylinder
8. arm moving cylinder
9. hoe moving cylinder
10. outrigger (strut, jack)
11. auxiliary attachment (blade)

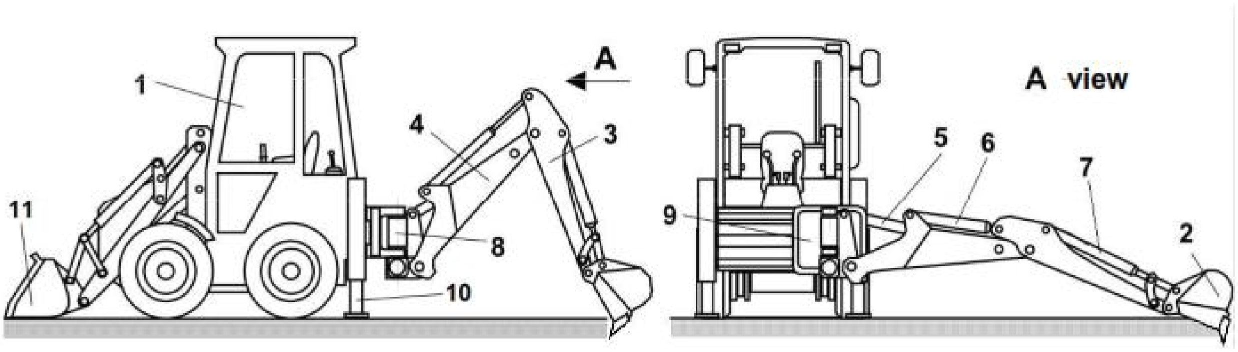


Backacter, wheel-mounted

Front shovel, track-mounted

Excavator (in action)

Backhoe excavators



1. wheel tractor
2. backacter
3. arm
4. slewing boom
5. boom cylinder
6. arm cylinder
7. bucket cylinder
8. slewing mechanism
9. suspension (base) plate
10. outrigger
11. front attachment (loader)

Hydraulic excavator attachments

Earthwork attachments

Backacter bucket

Auger

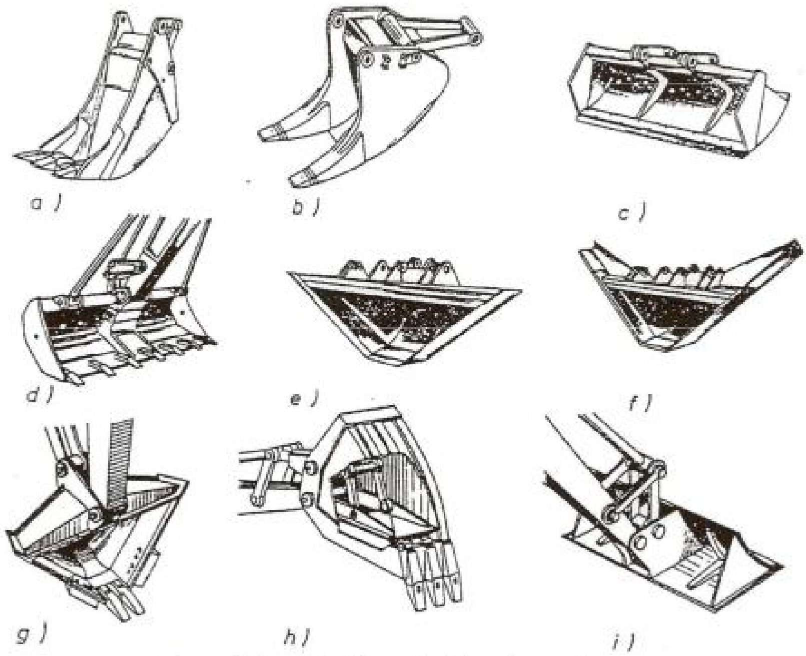
Ripper

Clamshell

Others: loading attachment; surface vibrator; roller compactor; bucket-lined or rotary terncher; profile buckets; sheet-wall driver; etc.

Hydraulic excavator attachments

Earthwork attachmenst



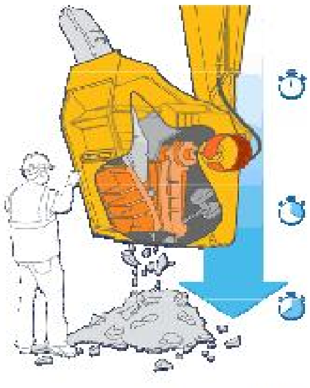
Special bucket-typed attachments

a. drainer; b. ripper; c. canal maintainer; d. ripper-cleaner; e. profile bucket; f. extended cutter; g. ripper-profiler; h. ejector; i. tamper

Hydraulic excavator attachments

Demolisher and Recycler attachments

Screen drum



Crusher (mill)

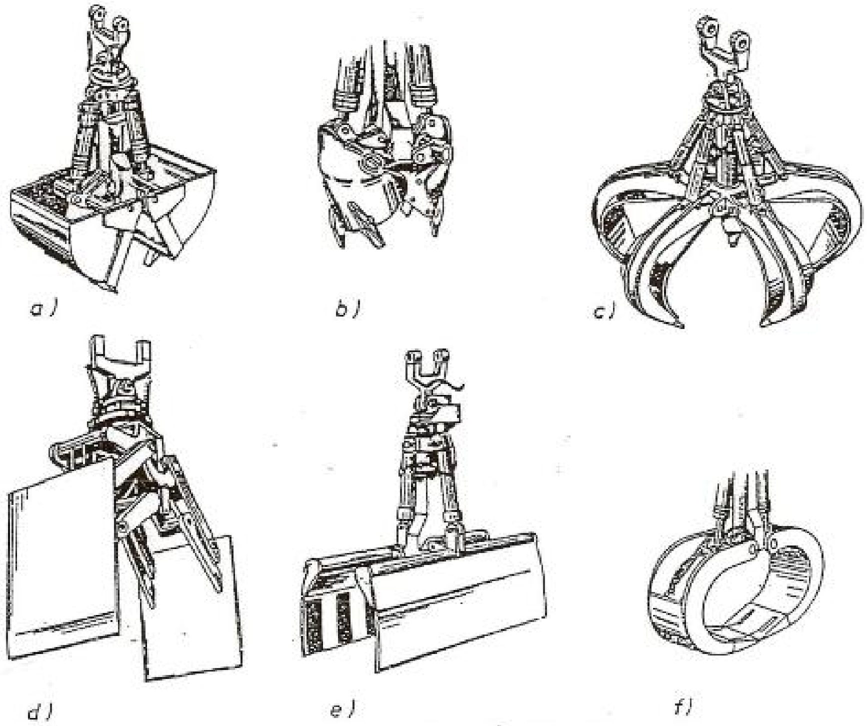
Breaker

Bucket-wheel

Snapper (cutter/jaw)

Hydraulic excavator attachments

Grabs, grips and loaders



Grabbing and loading attachments
a. clamshell; b. boring; c. fingered; d. bale grip; e. barrel/pipe grip; f. logger

Attachments

Clamshell bucket (for granular material)

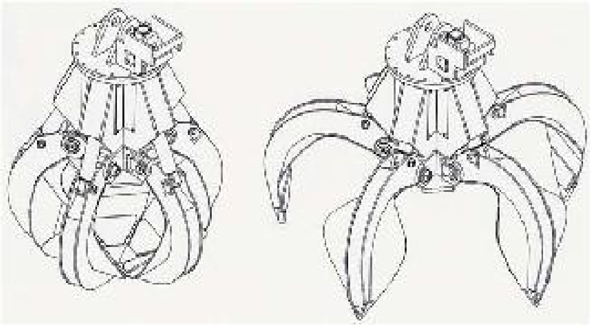
Breakers, Jaws
(for concrete, reinforced concrete and steel)

Screening adapter (for recycled material)

Others: loader bucket; drill; trunk-grip; cutter; trencher; fingered grips (for fibers or bars); crusher; vibro-plate; etc.

Sheet-wall piling equipment

Boring (auger) equipment



Fingered grip

Crusher adapter

Estimating performance (output) of intermittent excavators

Technical output:

Theoretical technical output (Q_t) assuming ideal circumstances (soft soil, less than 90º slewing angle, skilled operator, etc.)

$$Q_t = \frac{3600 \cdot q}{t_c} \qquad m^3/h$$

Where

- q = volume (capacity) of bucket [m³]
- t_c = $t_e + t_{sl1} + t_d + t_{sl2}$ cyle-time (single period) [s]
- t_e = extraction (charging/excavating/loading) time [s]
- t_{sl1} = (lifting and) slewing time (from) [s]
- t_d = discharging (unloading) time [s]
- t_{sl2} = slewing (and lowering) time (to) [s]

Adjusted technical output:

Corrected (adjusted) technical output (Q_a) considering construction of the excavator and behaviour of the soil

$$Q_a = Q_t \cdot \frac{k_f}{k_l} \qquad m^3/h$$

Where

- k_f = bucket fill factor (0,6 – 0,89)
- k_l = soil loosening factor (1,1 – 1,65)

Bucket fill factor is the ratio of volume of soil in the bucket and of technical volume (capacity) of the bucket.

Soil loosening factor is the ratio of volume of excavated loose soil in the bucket and that of compacted (natural) soil before extraction (excavation).

Effective (estimated) output:

Corrected adjusted output (Q_e) considering expected (experienced) time-efficiency of application (operation/site management)

$$Q_e = Q_a \cdot k_t \qquad m^3/h$$

Where

- k_t = time efficiency factor (0,45 – 0,83)

Time efficiency factor is the estimated ratio of effective (factual) and of „calendar" (scheduled) operation time of the equipment on site. It depends on lot of factors and circumstances such as: maintenance demand, skill of operator, idle (waiting) times, manoeuvre (relocating) times, etc.. Experienced values for hydraulic excavators are between 0,45 and 0,83.

Backhoe excavators

Features:

- Multifunctional front showel
- Draw beam (telescopic arm)
- Transversely slidable boom

FWHP-h is the measure of work performed by an engine based on average power generated and duration. Two major factors that impact the FWHP-h are the extent to which the engine will operate at full power and the actual time the unit will operate in an hour.

$$\text{TF} = \text{Time factor} = \frac{50 \text{ min}}{60} \times 100 = 83.3\%$$

$$\text{EF} = \text{Engine factor} = \frac{\%\text{ of time at full load}}{\%\text{ of time at less than full load}}$$

$$\text{OF} = \text{Operating factor} = \text{TF} \times \text{EF}$$

$$\text{Fuel consumed} = \text{OF} \times \text{Rate of consumption}$$

The amount of lubricating oil consumed includes the amount used during oil changes plus oil required between changes.

$$q = \frac{\text{FWHP} \times \text{OF} \times 0.006\ \#/\text{FWHP-hr}}{7.4\ \#/\text{gal}} = \frac{c}{t} = \frac{\text{gal}}{\text{hr}}$$

where OF is the operating factor, c is the crankcase capacity in gallons, t is the number of hours between changes, and # is pound.

Example 4

Hydraulic excavator.

160 FWHP — diesel engine
Cycle time = 20 s
Filling the dipper = 5 s at full power
Remainder of time = 15 s at half power
Assume shovel operates 50 min/h

$$TF = \frac{50}{60} \times 100 - 83.3\%$$

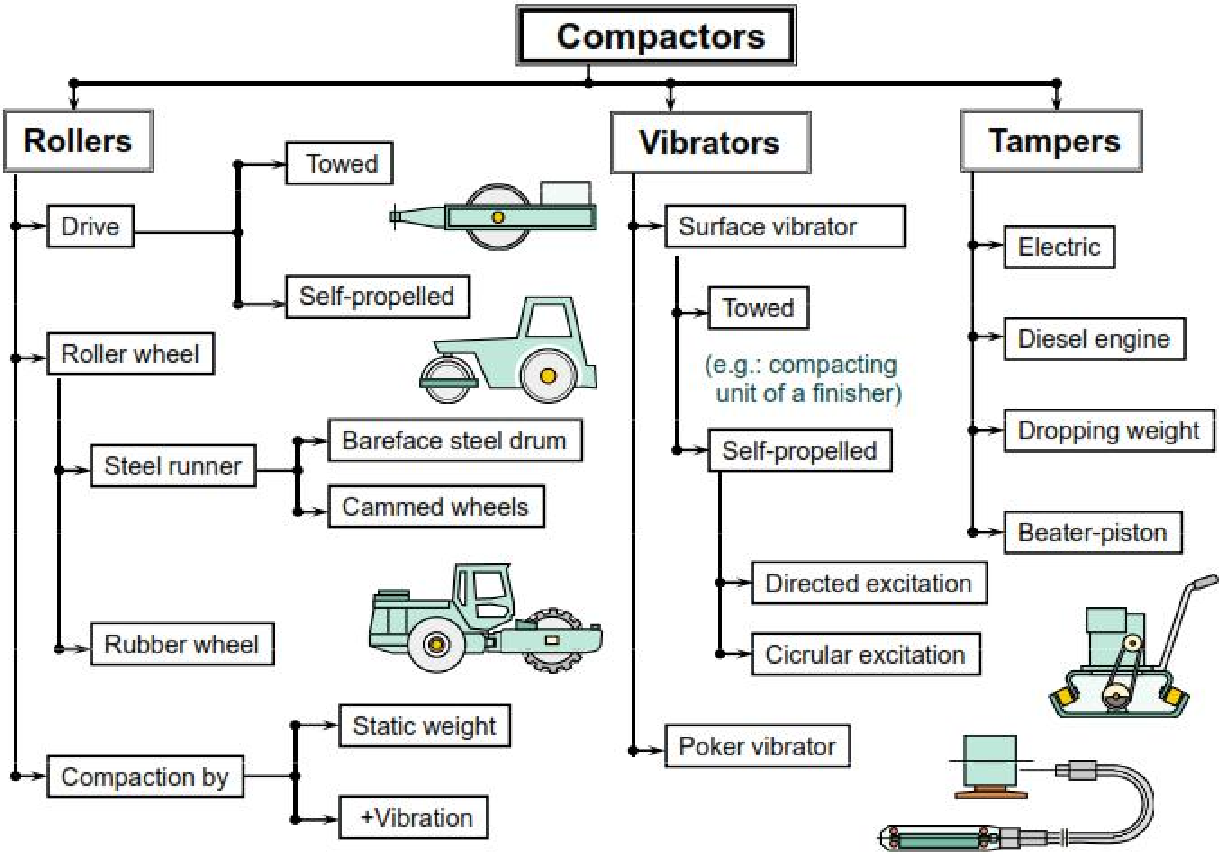
Engine factor:

Filling	$5/20 \times 1 = 0.25$	
Rest of Cycle	$15/20 \times .50 = \underline{0.375}$	
	TOTAL	0.625

$$OF = TF \times EF \times 0.625 \times 0.833 = 0.520$$

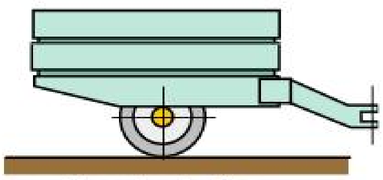
$$\frac{\text{Fuel consumed}}{\text{hr}} = 0.52 \times 160 \times 0.04 = 3.33 \text{ gal / hr}$$

COMPACTORS

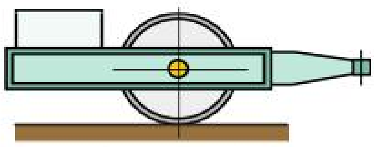


Towed rollers

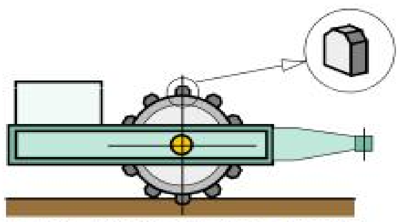
Basic types:



a. rubber-wheel roller



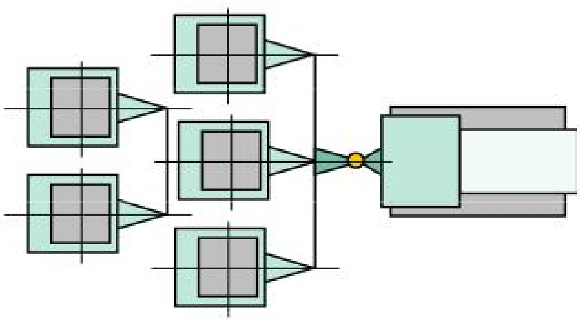
b. barefaced steel-drum



c. tamping (spiked/cammed) roller (for clay and adherent soil)

Features:

- Main application is soil compaction
- Towed individually or in groups
- Static load transferred to the soil can be controlled by weights mounted

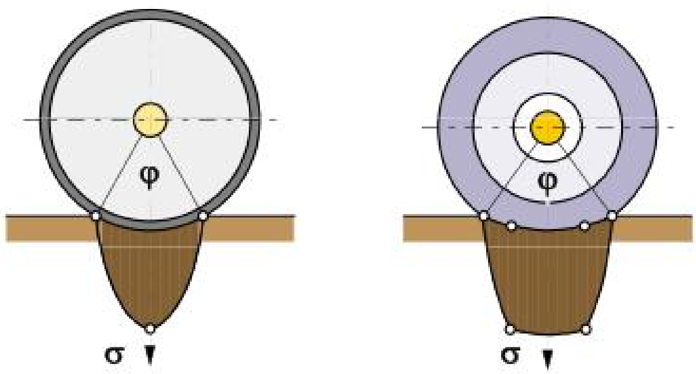


Towed group of static rollers

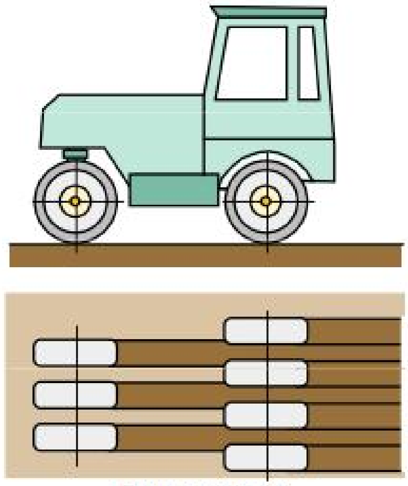
Self-propelled rollers

Typical configurations

a. bareface steel roller b. rubber-wheel roller



Soil compression (stress) under roller wheels



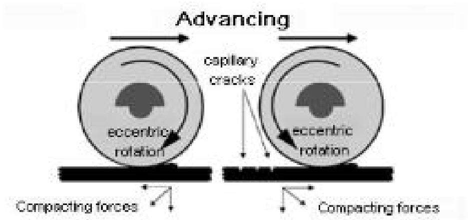
Rubber-wheel configuration

Vibratory compaction

Principle of vibratory compaction:

Grains of soil are effected by periodically alternating inertial forces. These forces make grain particles 'floating', so ordering is progressed without friction.

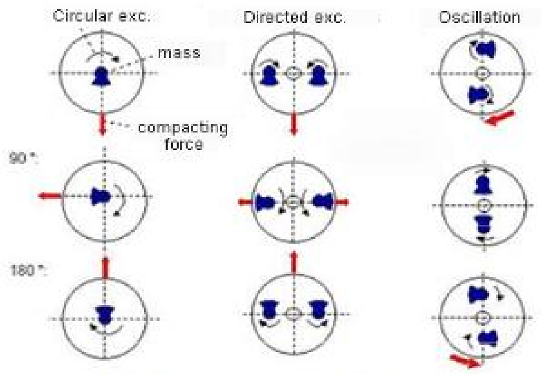
At vibratory compaction low amplitude high frequency excitation is used for loose soil or for deep layers. High amplitude low frequency excitation is used for cohesive soils in thin layers. Frequency of excitation should be close to characteristic frequency of the soil.



Effect of direction of rotation on the quality of compacted surface

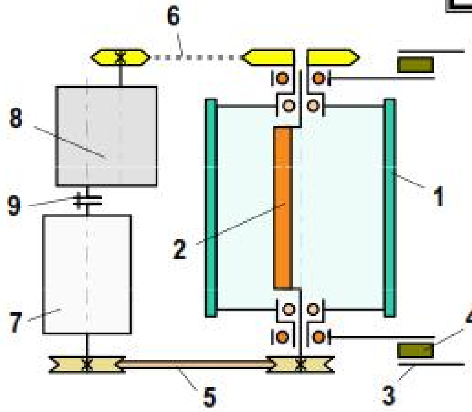
Ways of excitation:

- circular excitation: simple construction, single exciter unit, eccentric should always rotate in direction of advancing
- directed excitation: double exciter unit, generates both compressing and sharing forces in the soil simultaneously
- oscillation: the two exciter masses generate moment at the surface of the drum creating compressing and sharing forces in the soil, so grains are ordered horizontally. Vertical force is provided by the weight of the drum



Comparision of excitation methods

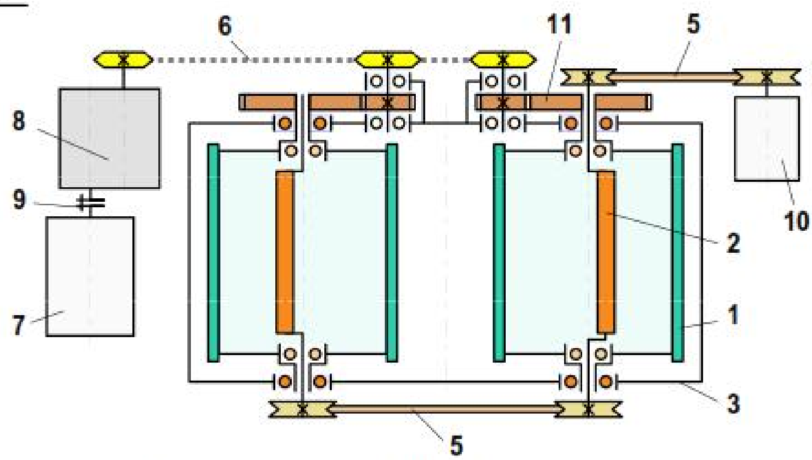
Vibratory roller drives



Roller Compactor: low working speed (v = 5 … 20 km/h)
Mechanic drive: gear-down unit (cogwheel gear, chain drive)
Hydraulic drive: low r/min hydro-motor, high driving torque

Excentric axle: high r/min value is needed for excitation and for efficient compaction (n = 2400 … 4500 r/min)

1. vibrating roller
2. excentric axle
3. carriage (frame)
4. rubber spring
5. V-belt drive
6. chain drive
7. engine
8. gear-down unit
9. clutch
10. exciting motor
11. cogwheel gear



Double engine drive (both roller wheels are driven)

Vibratory roller remote control

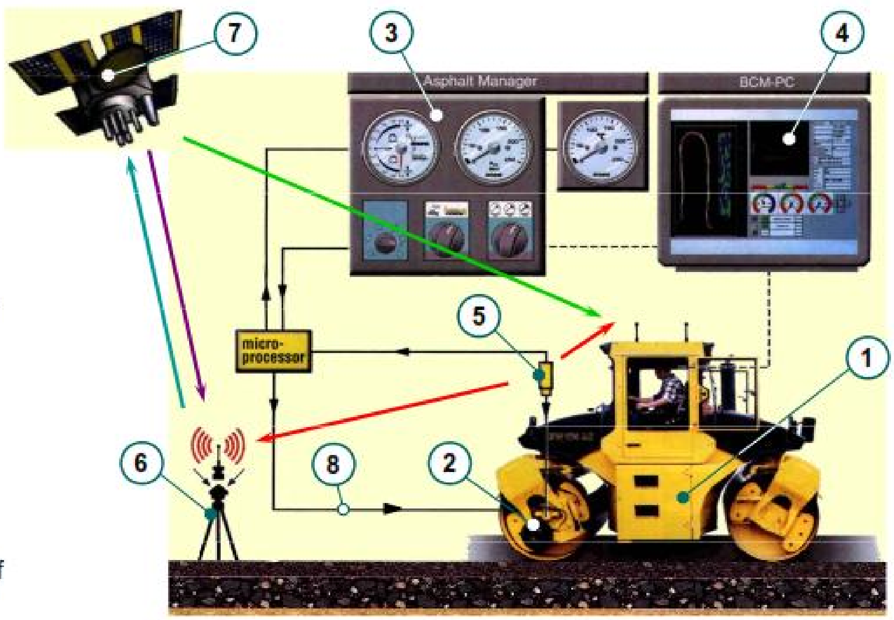
1. vibro roller
2. exciter unit
3. controlling unit
4. monitor
5. acceleration sensor
6. radio receiver-transmitter (database + controlling-monitoring system)
7. satellite
8. adjusting direction angle

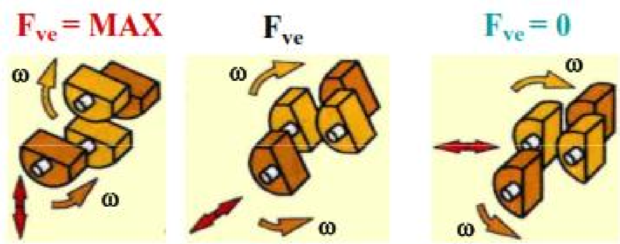
Controlling parameters:

dynamic elastic modulus of material to be compacted (via measuring acceleration)

Controlled parameters:

vertical excitation force (F_{ve})
frequency of vibration
working direction of the unit





TRUCKS AND HAULING EQUIPMENT

1. Trucks are hauling units

2. Trucks have high travel speeds when operating on suitable roads, provide relatively low hauling costs

3. Trucks provide a high degree of flexibility permitting modifications in the total hauling capacity of a fleet and adjustments for changing haul distances

4. Most trucks may be operated over any haul road for which the surface is sufficiently firm and smooth and on which the grades are not excessively steep.

TRUCKS CLASSIFICATION

Trucks may be classified according to a number of factors including:

1. The size and type of engine gasoline, diesel, butane, propane

2. The number of gears.

3. The kind of drive-two-wheel, four- wheel, six-wheel, etc

4. The number of wheels and axles and arrangement of driving wheels.

5. The method of dumping the load rear-clump, side-dump.

6. The class of material hauled-earth, rock, coal, ore, etc.

7. The capacity, in tons or cubic yards.

CAPACITY OF DUMP TRUCKS

There are three methods of expressing the capacities of trucks and wagons:

1) by the load which it will carry, expressed gravimetrically in tons.

2) by its struck volume (cu yd.).

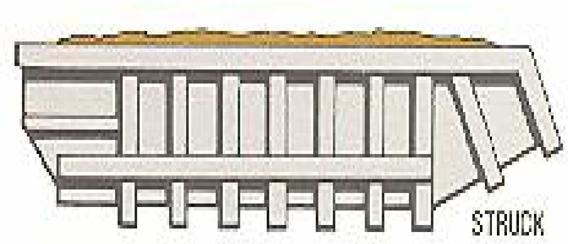
3) by its heaped volume (cu yd.).

The **struck capacity** of a truck is the volume of material which it will haul when it is filled level to the top of the sides of the body.

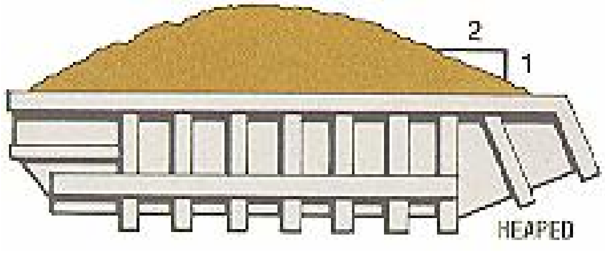
The **heaped capacity** is the volume of material, which it will haul when the load is heaped above the sides.

TRUCK CAPACITY

Manufacturer's specification sheets will list both struck and heaped capacities.



1- material measured straight across the top of the body



2- based on a 2:1 slope above hauler bodies.

EXAMPLE

Determine the maximum speed for the truck, whose specifications are given below, when it is hauling a load of 22 tons up a 6% grade on a haul road having a rolling resistance of 60 lb per ton: Engine: 239 fwhp

Capacity:

Struck, 14.7 cu yd

Heaped, 2:1, 18.3 cu yd

Net Weight (empty) = 36,860 lb

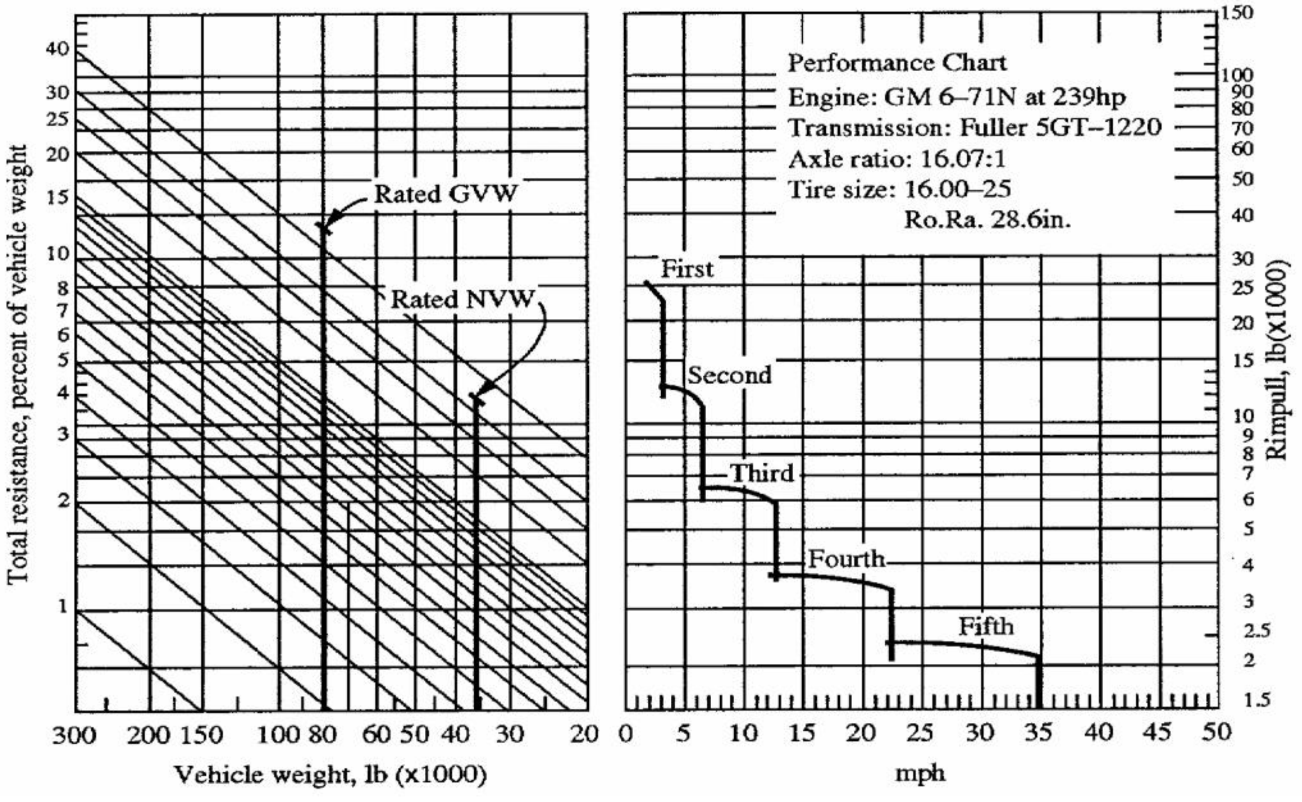
Payload = 44,000 lb

SOLUTION

$$\text{Gross Vehicle Weight} = 36{,}860 + 44{,}000 = 80{,}860 \text{ lb}$$

$$\text{Total Resistance} = rr + gr = \frac{60}{20} + 6 = 9\%$$

$$\text{Maximum Speed} \approx 6.5 \text{ mph (from Figure 1, or Fig.10 - 9 Text)}$$



USING SMALL TRUCKS COMPARED WITH LARGE TRUCKS

Advantages:

1) They are more flexible in maneuvering, which may be an advantage on short hauls.

2) They may have higher speeds.

3) There is less loss in production when one truck in a fleet breaks down.

4) It is easier to balance the number of trucks with the output of the excavator, which will reduce the time lost by the trucks or the excavator.

Disadvantages:

1) A small truck is more difficult for the excavator to load owing to the small target for depositing the bucket load.

2) More total spotting time is lost in positioning the trucks because of the larger number required.

3) More drivers are required to haul a given output of material.

4) The greater number of trucks increases the danger of units bunching at the pit, along the haul road, or at the dump,

5) The greater number of trucks required may increase the total investment in hauling equipment, with more expensive maintenance and repairs, and more parts to stock.

Trenching Machine

Trenching machine, also called Ditcher, or Digging Wheel, excavation machine employing a wheel fitted with rim buckets, or with a boom or ladder on which an endless chain of buckets or scrapers revolves. The machine is self-propelled on rubber tires or crawlers (continuous metal treads driven by wheels). As the machine moves forward, it rotates the ladder or wheel so that the buckets dig at their forward edge. They dump onto a conveyor belt or a chute that piles the cuttings on either side. Trenching machines can be equipped to cut hard ground and even soft rock, but they encounter difficulty with boulders .

A trencher is a piece of construction equipment used to dig trenches, typically for laying pipes or cables, or for drainage. Trenchers range in size from walk-behind models to heavy tracked heavy equipment. Trenchers come in two designs, chain trencher or wheel trencher.

The First Trenching Machine

The first trencher was a mechanical machine that dug ditches. The Buckeye No. 88 was developed by James B. Hill in 1893 at the Bowling Green Foundry and Machine Co. in Bowling Green, Ohio. Upon his invention, Hill founded the Van Buren Heck & Marvin Co. in 1902 to produce and manufacture his invention. The company name was short-lived and it eventually became the Buckeye Traction Ditcher Co. in 1906, a company that became well known for its contribution to developing trenching machinery.

Other companies began to see the demands for trenching machines. Companies such as the Cleveland Trencher Co., the Parsons Co., and the Barber-Greene Co. helped catapult the trenching machine into what it is today.

Hydraulic Trenchers

The first trenchers were made mechanical and consisted of a large number of parts such as drive shafts and gearboxes. After World War II, trenchers were driven and operated by hydraulics. At this time, they also started to evolve and become more advanced. With the addition of drive trains and hydraulic motors and rams, trenchers were capable of moving faster and completing the jobs sooner.

Advantages

Trenching machines' advantages become more vivid in comparison with an alternative method of trenching. For example using of bucket excavators don't guarantee distinct uniform and equal depth, while lumps of spoil cannot be used for backfilling at times. Bucket excavator's productiveness is well below due discrete nature of work bucket filling-in, soil excavation from trenches, bucket dumping, bucket's return to the trench, excavator's move forward. Trenching machine in its turn performs digging continuously, self-moving at speed set by the operating device.

Types

Trenchers come in different sizes and may use different digging implements, depending on the required width and depth of the trench and the hardness of the surface to be cut. Trenchers must be handled with extreme care because they are very dangerous equipment.

Trenchers come in two designs, chain trencher or wheel trencher.

Chain

A chain trencher is a machine that drives a chain to dig trenches. Its action is similar to a chain saw and the chain moves around a blade to excavate the soil. They are used for large commercial irrigation projects where digging into hard soil is a problem. The width of the trench needs to be kept to a minimum where a deep trench is required. Cost to hire varies depending on size and is usually expensive.

Positives:
- Used for hard to reach areas.
- Used where a large job is required.
- Fast digging.
- Removes soil from excavation.
- Reduced labour costs.
- Reduced physical labour.

Cons:
- Expensive to hire and move around (truck required).
- Not suitable for small domestic irrigation jobs.

Ditch Witch chain trencher

Wheel

The wheel trencher consists of a wheel with a number of buckets attached sitting atop a set of crawler tracks. The wheel rotates as it approaches the ground and the bucket it used for digging the dirt from the trench. The buckets move in one continuous stream and when the bucket reaches the highest point it can reach, the dirt is tipped out of the bucket and is removed through a chute onto a conveyor belt that runs laterally to the wheel. The process is consistently occurring as the crawler feet move in the direction the trenches are being excavated.

Wheel trencher attached to New Holland tractor

Ditch Witch RT70

Wheel trencher

Also there are a number of different companies that manufacture trenching machines but the most common machines are listed below.

Excavators

An excavator is a track driven machine, which operates by scooping the soil and depositing it beside the trench. They are used for large commercial irrigation jobs where large pipes will be laid or multiple pipes will be installed in the same trench. Cost to hire is based on an hourly rate and is hired as an owner/operator with a truck as transport.

Pros:
- Track machines are less likely to cause damage to landscapes as they minimise damage to the soil/turf.
- Long reach of boom arm.
- Able to dig large holes very quickly.

Cons:
- The transport of the machinery to site is expensive.

Disc or blade trencher

These are small motor driven machines designed specifically for digging small trenches usually 80mm x 200mm. They are inexpensive to purchase, are fast and make light work of digging. They are easy to transport in the back of a ute.

Pros:
- Cost effective.

Cons:
- Safety must be considered and operators should be trained in the trencher's correct use.
- Blades can wear out quickly and require replacement (depending on soil conditions).

Others: Skid steer machines

These are machines with buckets that are used to move soil and are useful for levelling and general earth works. Called **bobcats** in some places, skid steer machines are not generally used to dig trenches, as this may require adapting the machine for the purpose. They are hired by an hourly rate for the owner/operator and need a truck for transport.

Pros:

- Useful for levelling and returning soil from excavations. Can be used in small spaces.
- Fast with good results - high quality finish.
- The weight of the machine helps compact filled in trenches.

Cons:

- Expensive to hire and can cause damage to recently installed irrigation systems by running over sprinklers and pipes.

Hand tools

Powered trenching machines are often quite costly to buy (or even hire) and are usually only needed on very large jobs. So when digging trenches you are more likely to use one of the following hand tools. Each of these has safety requirements for use and in particular, safety boots should always be worn.

Trenching shovel

A trenching shovel makes light work of narrow trenches as it only removes soil wide enough for pipe work.

The square mouth of the shovel helps keep a flatbed for the pipe to lie in. The handle (made either of plastic or wood) should be light and strong and preferably long handled to ease the strain on the back.

Pros:
- Lightweight, narrow and purpose built for hand digging trenches.
- Inexpensive
- Available from most hardware stores.

Cons:
- Only suitable for digging trenches and small excavations.

Turf Cutter

These are small motor driven machines that have a V shaped blade attachment for cutting into the turf. This allows for the removal for the turf sod whilst creating the trench at the same time. They are hand-operated machines.

Pros:
- Useful for returning the sod back into its original place resulting in quick site recovery.
- Inexpensive to operate.

Cons:
- Not suitable for deep trenches.

- Hand pushed and slow to operate.
- Cumbersome to use especially in tight spaces such as corners.

Spade

Spades can be used to cut trenches in existing lawn, as they have a sharp blade. They are inexpensive and available from most hardware stores.

Pros:
- A multi-purpose-digging tool.
- Its sharp edge allows it to cut though the soil.
- Spades are readily available and inexpensive.

Cons:
- Not suitable for lifting soil.

Shovels

There are generally two types of shovels used in industry: the **wide mouth shovel** and the **pointed mouth shovel**.

The wide mouth shovel is useful for picking up sand and other materials from hard surfaces and the pointed mouth shovel is used for excavation when large amounts of sand need to be removed.

Pros:
- Shovels are useful for lifting and moving small amounts of soil.
- Readily available.

Cons:
- Not a digging tool.

Pick axe

Pick axes are another useful tool to have around when you need to excavate trenches. They can be used to cut through existing roots or hard ground to create trenches.

Pros:
- Useful for penetrating hard ground and breaking it up so that the trench can then be prepared with a trenching shovel.

Cons:
- This is a single purpose tool.
- Heads may be prone to coming loose as the axes age.

Rake

Rakes are inexpensive and are often used to clear rocky or uneven ground prior to excavation

Rakes can be used to tidy up sites **after** trenches have been excavated and they are also used to refill trenches after pipes have been laid.

Pros:
- Inexpensive and a 'must have' piece of equipment for the clean-up stage at the end of the irrigation installation job.

Cons:
- There are many types of rakes available and you must select the correct one for the job at hand.

Hand trowel

Hand trowels are useful tools for clearing trenches after the pipe is laid. They are also good for small excavations.

Pros:
- Inexpensive and handy for very small spaces.

Cons:
- Suitable only for very small excavations.

Mattock

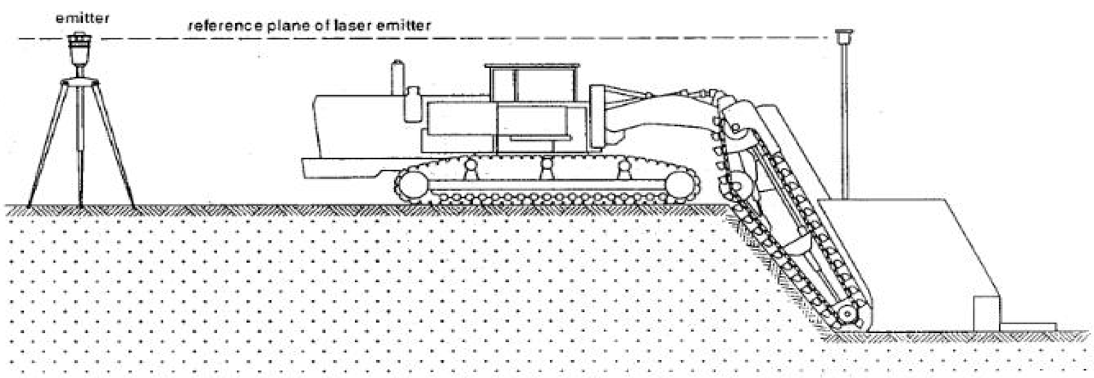
Mattocks are useful for cleaning out trenches in sand or breaking soil when digging is hard.

Pros: • Inexpensive and handy for many jobs.

Cons: • Heads may be prone to coming loose.

Nowadays, most drainage machines have grade control by laser. An emitter, placed on a tripod near the edge of the field, establishes an adjustable reference plane over the field by means of a rotating laser beam (Figure). A receiver, mounted on the digging part of the drainage machine, picks up the signal. The control system of the machine continuously keeps a fixed mark in the laser plane. One position of the emitter can serve the installation of a fairly large number of drains.

Grade control by laser for drain pipe installation



Heavy Equipment Maintenance and Repair

Maintenance

All actions necessary for retaining an item, or restoring to it, a serviceable condition, include servicing, repair, modification, overhaul, inspection and condition verification

1. Increase availability of a system
2. Keep system's equipment in working order

Purpose of Maintenance

1. Attempt to maximize performance of production equipment efficiently and regularly
2. Prevent breakdown or failures
3. Minimize production loss from failures
4. Increase reliability of the operating systems

Principle Objectives in Maintenance

1. To achieve product quality and customer satisfaction through adjusted and serviced equipment
2. Maximize useful life of equipment
3. Keep equipment safe and prevent safety hazards
4. Minimize frequency and severity of interruptions
5. Maximize production capacity – through high utilization of facility

Problems in Maintenance

1. Lack of management attention to maintenance
2. Little participation by accounting in analyzing and reporting costs
3. Difficulties in applying quantitative analysis
4. Difficulties in obtaining time and cost estimates for maintenance works
5. Difficulties in measuring performance

Problems Exist Due To:

1. Failure to develop written objectives and policy
2. Inadequate budgetary control
3. Inadequate control procedures for work order, service requests etc.
4. Infrequent use of standards
5. To control maintenance work
6. Absence of cost reports to aid maintenance planning and control system

Maintenance Objectives

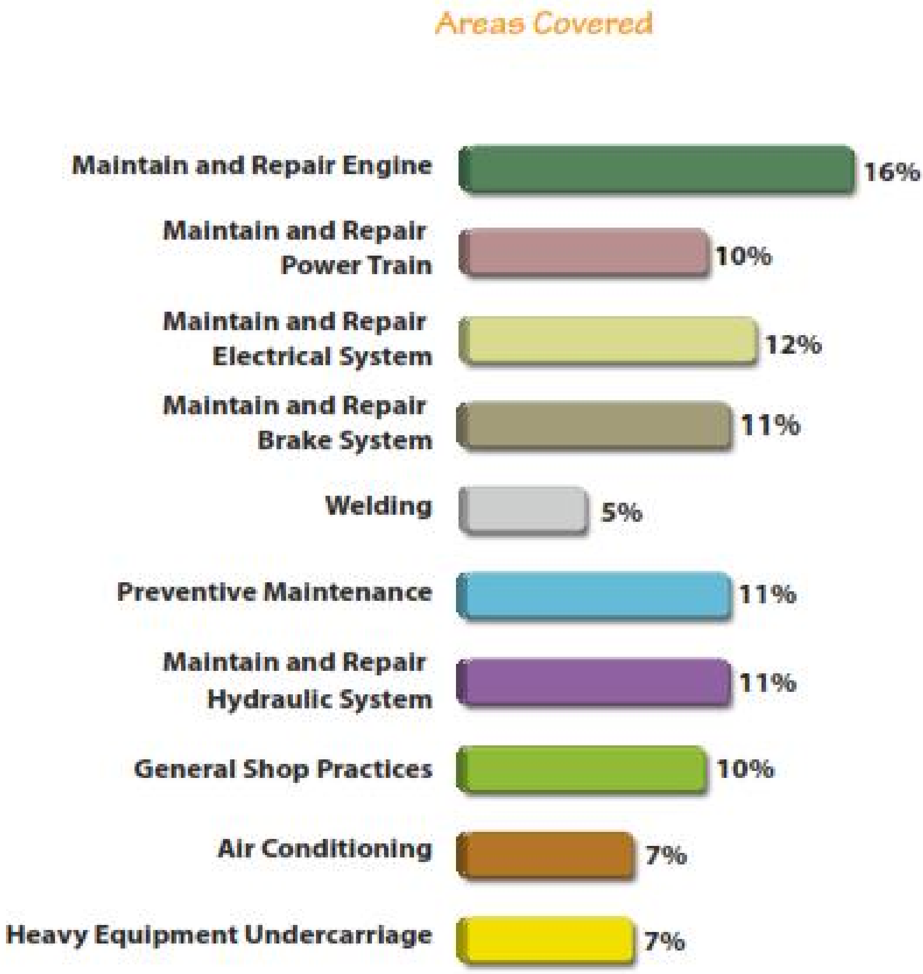
1. Must be consistent with the goals of production (cost, quality, delivery, safety)
2. Must be comprehensive and include specific responsibilities

Maintenance Costs

1. Cost to replace or repair
2. Losses of output
3. Delayed shipment
4. Scrap and rework

Types of Maintenance

1. Maintenance may be classified into four categories:
2. (some authors prefer three categories- scheduled and preventive maintenances are merged)
3. Corrective or Breakdown maintenance
4. Scheduled maintenance
5. Preventive maintenance
6. Predictive (Condition-based) maintenance



Specific_ Competencies and Skills Tested in this Assessment

Maintain and Repair Engine

- Change oil and filters
- Maintain fuel system
- Apply knowledge of 4-stroke engines
- Maintain cooling system
- Maintain intake and exhaust systems

Maintain and Repair Power Train

- Demonstrate knowledge of hydrostatic power train
- Service and repair final drives
- Service power shift transmissions
- Service and inspect drive lines
- Service and maintain mechanical transmissions

Maintain and Repair Electrical System

- Maintain/repair electronic controls
- Service and test starting system
- Service and test charging system
- Service and test battery
- Maintain basic electrical system (lighting accessories)

Maintain and Repair Brake System

- Inspect air brake systems
- Apply knowledge of wet brake systems
- Apply knowledge of hydraulic brake systems
- Identify brake components

Specific Competencies and Skills

Welding

- Identify various types and components of metals
- Apply knowledge of shielded metal arc welding
- Demonstrate safe use of welding and fabrication tools

Preventive Maintenance

- Inspect and maintain tire performance
- Monitor gauges and warning lights
- Inspect hydraulic system
- Adhere to maintenance schedules and manage record keeping
- Measure and maintain oil and fluid levels
- Perform oil sampling

Specific Competencies and Skills (continued)

Maintain and Repair Hydraulic System

- Identify basic hydraulic system components
- Describe operation of various hydraulic pumps
- Service and troubleshoot hydraulic system, valves, and pressure controls
- Apply knowledge of hydraulic schematic symbols

- Apply knowledge of hydraulic circuits
- Service and rebuild hydraulic cylinders

General Shop Practices

- Identify personal protective equipment (PPEs)
- Select proper fasteners
- Select and use sealants properly
- Perform drilling and tapping operations
- Describe proper use of hand tools
- Demonstrate safe use of jacks and lifting equipment

Specific Competencies and Skills

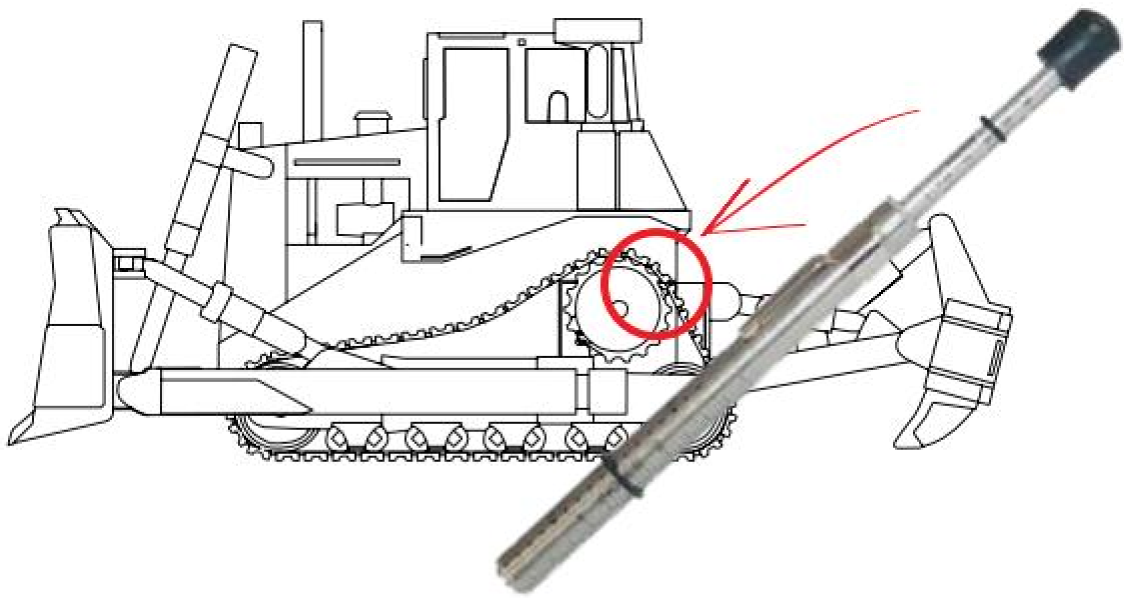
Air Conditioning

- Identify air conditioning components
- Maintain air conditioning system
- Recover and recharge air conditioning systems
- Troubleshoot air conditioning malfunctions

Heavy Equipment Undercarriage

- Inspect undercarriage and components
- Demonstrate appropriate use of ground engaging equipment
- Perform track tension adjustments

• Demonstrate appropriate blocking/cribbing techniques



Sample questions

1. **Why do we need maintenance?**
2. **What are the costs of doing maintenance?**
3. **What are the costs of not doing maintenance?**
4. **What are the benefits of maintenance?**
5. **How can maintenance increase profitability of company?**
6. **Choose the correct answer :**

Insufficient valve clearance can cause

A. coolant leakage

B. a burnt valve

C. worn valve guides

D. oil leakage

Spur gears have teeth that are

A. curved

B. straight

C. herringboned

D. beveled

The electrolyte in a battery is a solution of water and

A. sulfuric acid

B. baking soda

C. viscous oil

D. hydrogen sulfide

One sign of a defective hydraulic brake system is

A. low gas mileage

B. uneven tire wear

C. non-operational stoplights

D. low brake fluid level

The resistance of a liquid to flow is

A. viscosity

B. velocity

C. reciprocity

D. density

The lip on a wheel seal must face toward the

A. air

B. vehicle

C. fluid

D. brakes

When conducting a starter current-draw test, the maximum time an engine should be cranked is

A. 5 seconds

B. 30 seconds

C. 60 seconds

D. 90 seconds

When checking air-pressure drop, the technician should check with

A. the spring brake applied and the foot brake released

B. a maximum of 45 pounds

C. the spring brake released and the foot brake applied

D. the supply tank drained

7. **Put the correct answer in the following blanks :**

The weld between two metal joints on the same plane is called a _______ weld.

A. pass

B. butt

C. bevel

D. tack

A hydrostatic circuit is considered to be a/an _______ system.

A. open center

B. closed center

C. closed loop

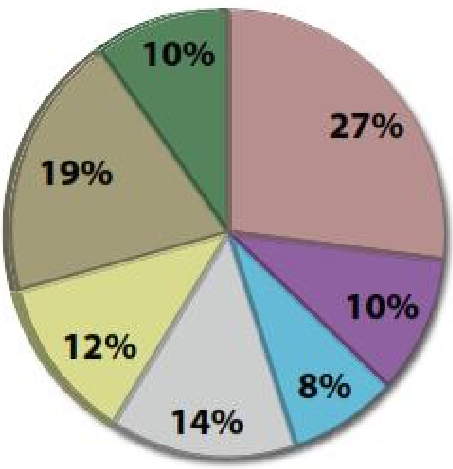
D. centrifugal flow

performance assessments

NOCTI performance assessments allow individuals to demonstrate their acquired skills by completing actual jobs using the tools, materials, machines, and equipment related to the technical area.

Administration Time: 2 hours and 25 minutes

Number of Jobs: 7



Areas Covered:

10% Test Cooling System

Perform a cap pressure test, diagnose system pressure loss, document leaks in system, and time to complete job 1.

19% Electrical Testing

Perform a battery discharge test, a starter draw test, an alternator maximum

12% Adjust Valve Clearance

Demonstrate accuracy of specifications, accuracy of positioning engine for valve adjustment, accuracy of initial measurement for valve clearance, accuracy of final measurement for valve clearance, and time to complete job 3.

14% Set Carrier Bearing Ring and Pinion Backlash

Set carrier ring and pinion backlash, measure and record backlash, and time to complete job 4.

8% Identify Brake Components

Identify various brake components, and time to complete job 5.

10% Measure and Adjust Track

Lock-out/tag-out, record specifications, measure and record track measurement, circle corrective action needed, adjust track and record adjusted measurement, remove lock-out/tag-out, and time to complete job 6.

27% Cut and Weld Steel

Setup and operation of oxyacetylene cutting, welder set-up, accuracy of cut, accuracy of weld, penetration, appearance of weld, quality of cut edges, and time to complete job 7.

Cut and Weld Steel

Maximum Time: 20 minutes

Participant Activity: The participant will use the proper tools and equipment to cut steel using the pattern provided. Attach the cut piece as shown in the drawing provided using a butt weld.

SHOVEL LOADER

EXCAVATOR

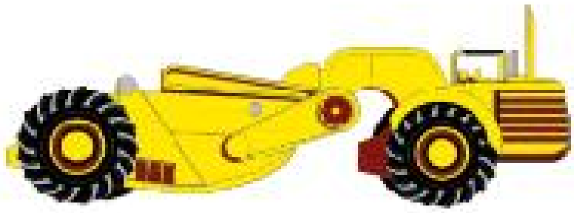
VIBRATING ROLLER

BULL DOZER

TRACTOR

GRADER

DUMPER



SCRAPER

<table>
<tr><td rowspan="2">Subject Name</td><td>باللغة العربية</td><td>مكائن ومعدات استصلاح اراضي</td><td rowspan="2">Study Year</td><td colspan="3">Weekly hours</td></tr>
<tr><td>باللغة الإنكليزية</td><td>Reclamation land Equipment</td><td>Theo</td><td>Pract</td><td>Total</td></tr>
<tr><td colspan="2">Study language</td><td>English</td><td>Second</td><td>1</td><td>3</td><td>4</td></tr>
</table>

Objectives :-

General :- Enable the student to use reclamation land equipment and its Maintenance .

Special :- Enable the student to use the machine with correct methods and How to repairs it .

Theoretical syllabus	
Details	**Week**
Tractors – tractor uses – types of tractors – Gradability .	1
Bull Dozers – uses – the difference between crawler and wheel Mounted bull dozers .	2
Types of equipment used – hydrowlic system .	3
The out put of bull dozer – repairs and maintenance .	4
Front – end – loaders – uses – types and sizes – types of equipment.	5
The out put of front – end – loaders – problemes – maintenance .	6
Scrapers – types and sizes – operating Ascraper- cycle time for Scraper .	7
Types of equipment – hydraulic system – maintenance – problems.	8
Grader – types of grader – types of equipments – uses .	9
The out put of grader – hydraulic system – maintenance .	10
Excavating equipment – types of equipment – drag lines – the	11

Out put .	
Hydraulic drag lines – the basic parts – hydraulic system – Maintenance .	12
A cable – controlled drag line – the basic parts – depth of cut – Maintenance .	13
Trenching machines – the basic parts – types of trenching mach	14
Hydraulic system of trenching machines – the output – maint	15

Practical syllabus

Details	**week**
Simplyfing assumption about the equipments- uses- general safty.	1
Types of bulldozers – the control gages – general safty .	2
Practical application – how to repair the machin in the field .	3
Calberation – practical application .	4
Control gages of loaders – practical application .	5
Repairs and maintenance – general safty .	6
Types of scraper – control gages – practical application .	7
Sciemtific visit to any reclamation projest .	8
Types of grader – control gages – general safty .	9
Praetical application – calberation – maintenance .	10
A cable – controlled drag line – control gages – the basic parts .	11
Hydraulic drag lines – practical application .	12
Calbe ration – main tenance – practical application .	13
The basic parts of trenching machines – control gages – general Safty .	14
Practical application – maintenance .	15

CONVERSION TABLES & FORMULAS

Crude Oil: Orange Juice:

1 barrel = 42 US gallons = 34.97 UK (imperial) 1 metric ton of 65 degree brix = 344.8 gallons at

gallons = 0.136 tonne (approx) 42 degree brix

1 barrel per day (b/d) = 50 tonnes per year (approx) 1 metric ton of 65 degree brix = 1,405.88 gallons at

Single Strength Equivalent (SSE)

1 Bushel Equals: Bushels to Tonnes:

Wheat and Soybeans = 60 lbs. Wheat and Soybeans = bushels x 0.027216

Corn, Sorghum and Rye = 56 lbs. Barley Grain = bushels = 0.21772

Barley Grain = 48 lbs. Corn, Sorghum and Rye = bushels = 0.025400

Barley Malt = 34 lbs. Oats = bushels x 0.014515

Oats = 32 lbs.

Cotton Bales: Extraction Rates:

US = 480 lb. (the statistical net bale used by the 100 Grain = 72 Bread Flour

USDA and ICAC) 100 Raw Sugar = 92 Refined Sugar

Brazil = 397 lb. (metric bale = 180 kg) 100 Paddy Rice = 65 Milled Rice

India = 392 lb. (metric bale = 170 kg) 100 Milk = 4 butter

1 ton Barley = 105 Proof Gal. Whisky

Yields: 1 Tonne (metric ton) Equals:

Wheat: bushels per acre x 0.6725 = 1 cubic meter of water

quintals per hectare 2204.622 lbs.

Rye, Corn: bushels per acre x 0.6277 = 1,000 kilograms

quintals per hectare 22.046 hundredweight

Barley Grain: bushels per acre x 0.5380 = 10 quintals

quintals per hectare 36.7437 bushels of Wheat or Soybeans

Oats: bushels per acre x 0.3587 = 39.3679 bushels of Corn, Sorghum or Rye

quintals per hectare 45.9296 bushels of Barley Grain

68.8944 bushels of Oats

Live to Lean Hog Conversion: Precious Metals:

Live Hog Price/0.74 = Lean Hog Price 24 carat implies pure gold

Linear Measurements

Kilometer = 1,000 meters = 0 .6214 miles

Hectometer = 100 meters = 1,093.67 yards

Decameter = 10 meters = 32.81 feet

Meter = 1 meter = 39.37 inches

Decimeter = 1/10 meter = 3.94 inches

Centimeter = 1/100 meter = .394 inches

Millimeter = 1/1,000 meter = .0394 inches

1 inch = 2.54 centimeters

12 inches = 1 foot = 30.48 centimeters

3 feet = 1 yard = 91.44 centimeters

6 feet = 1 fathom = 1.829 meters

5280 feet = 1 mile = 1.61 kilometers

1 league is approximately 3 statute or 3 nautical miles

To convert kilometers into miles, multiply by 0.6214.

To convert miles into kilometers, divide by 0 .6214.

Weight Conversion

1 kilogram = 2.2046 pounds

1 kilogram = .0011 short tons

1 kilogram = .0010 metric tons

1 kilogram = .00098 long tons

1 short ton = 2,000 pounds

1 short ton = 907.18 kilograms

1 short ton = .9072 metric tons

1 short ton = .8929 long tons

1 long ton = 2,240 pounds

1 long ton = 1,016.05 kilograms

1 long ton = 1.0160 metric tons

1 metric ton = 2,204.6 pounds

1 metric ton = 1,000 kilograms

1 ounce (avoirdupois) = 1/16 pound = 28.35 grams = 437½ grains

1 ounce (troy) = 1/12 pound = 480 grain

REFERENCES

***1**. Associated Equipment Distributors. Undated. Rental Rates and Specifications. Associated Equipment Distributor, Chicago, IL.*

***2.** Carson, A.B. 1961. General Excavation Methods. McGraw-Hill, New York.*

Caterpillar. 1993. Caterpillar Performance Handbook, Caterpillar, Peoria, IL.

Halpin, D.W. and Riggs, L.S. 1992. Planning and Analysis of Construction Operation. John Wiley & Sons,New York.

***3.** Hendrickson, C. and Au, T. Project Management for Construction. Prentice Hall, Englewood Cliffs, NJ.*

***4**. Iseley, T. and Gokhale, S. 1997. Trenchless Installation of Conduits Beneath Roadways. Synthesis of Highway Practice 242, Transportation Research Board, National Academy Press, Washington, DC.*

***5**. Iseley, T. and Tanwani, R., Eds., Trenchless Excavation Construction Equipment and Methods Manual,2nd ed., 1993. p. 1–3. National Utility Contractors Association, Arlington, VA.*

***6.** Peurifoy, R.L. and Schexnayder, C.J. 2002. Construction Planning, Equipment and Methods, 6 ed.McGraw-Hill, New York.*

***7**. "Caterpillar Tractor Co. List of Deals". Lehman Brothers Collection. President and Fellows of Harvard College. 2010. 06-11-2010. 06-11-2010. "In 1925 Holt and C.W. Best's company merged to form the Caterpillar Tractor Company."*

***8**."Caterpillar gives Ontario harsh lesson in union-busting by shutting locomotive plant". The Star (Toronto). 2012-02-05.*

***9**. "Mark's Work Wearhouse pulls Caterpillar boots to protest closure of London plant". The Star (Toronto). 2012-02-05.*

***10.**. "Caterpillar Workers Ratify Deal They Dislike". New York Times (New York). 2012-08-17.*

***11**. Illinois Department Of Natural Resources October 25, 2007. Retrieved May 8, 2008*

12. *"Cat backs plan to cut school bus emissions". Trailer/Body Builders. Retrieved 2007-08-31.*

13. *"Diesel Engine School Bus Retrofit Technology Workshop, Baltimore, MD, April 29, 2004". Maryland Department of the Environment. Retrieved 2007-08-31.*

14*.Million from Caterpillar Inc. to The Nature Conservancy Launches Ambitious Global Freshwater River Project and Establishes a Great Rivers Center". The Nature Conservancy. Archived from the original on December 14, 2006. Retrieved 2007-08-31.*

15. *http://noticias.uol.com.br/cotidiano/2009/08/12/ult5772u4933.jhtm*

16. *http://www2.alo.se/Intl/Pages/history.ept Ålö history: From innovation to world-leading position*

17. *"Use Powerful Excavator Building Tamiami Trail". The Weekly Miami Metropolis. September 15, 1916. Retrieved 29 December 2013.*

18. *"First Wind Farm In Nh To Begin Operation". Bangor Daily News. Jan 9, 2006. Retrieved 29 December 2013.*

19. *"Industrial Expe ..Lasso Gives More Power To The Hy-Mac Elbow". The Glasgow Herald. June 9, 1962. Retrieved 29 December 2013.*

20. *-F, Kevin. "Types of Excavators and Their Uses". Retrieved 29 December 2013.*

21. *"Tips to Help You Operate Your Mini Excavator". Retrieved 29 December 2013.*

22. *How it works: The track motor spool in an Excavator*

23. *http://www.yanmar.com/construction/products/excavators/*

24. *http://www.mikrofyn.com*

25. *Orlemann, Eric (2007). "The Caterpillar Century" (2nd ed.). Motorbooks International. p. 118. ISBN 978-0-7603-2961-0. Retrieved 7 March 2012.*

26. *"Dan Albone, English inventor, 1902". The Science and Society Picture Library. Retrieved 2013-08-30.*

27. *"Smithsonian Museum of American History". Hart Parr #3. Retrieved 2010-11-29.*
28. *Houghton Mifflin (2000). The American Heritage Dictionary of the English Language (4th ed.). Boston and New York: Houghton Mifflin. p. 1829. ISBN 978-0-395-82517-4.*
29*.Merriam-Webster Unabridged (MWU). (Online subscription-based reference service of Merriam-Webster, based on Webster's Third New International Dictionary, Unabridged. Merriam-Webster, 2002.) Headword tractor. Accessed 2007-09-22.*
30. *Tractor. (etymology). Online Etymology Dictionary. Retrieved 2008-06-02.*
31. *Hodge, James (1973). Richard Trevithick (Lifelines 6). Shire Publications. p. 30. ISBN 0-85263-177-4.*
32*. Letourneau earthmovers, Eric C. Orlemann, MBI, ISBN 0-7603-0840-3*
33. *The Wabco Archive Wheel-Tractor Scrapers (Global General Publishing Pty Ltd,2011) ISBN 978-0-9871503-0-1*