5.5.1 Standard Stockpile

Standard stockpiles, like the one shown in *Figure 13-27*, are constructed by performing basic bucket loading and dumping techniques.

Figure 13-27 – Standard stockpile.

The steps to construct a standard stockpile are as follows:

Step 1. Move the front-end loader forward until the front tires contact the bank.

Step 2. Move the lift control lever to raise the bucket all the way.

Step 3. Move the tilt control lever to slowly tilt the bucket to the dump position.

Step 4. Pull the tilt control lever to tilt the bucket back to the standard bucket position.

Step 5. Back the front-end loader from the stockpile and lower the bucket to about 10-14 inches off the ground.

Step 6. Back the front-end loader to the start of the work area.

Step 7. Repeat the above steps until all the material is stockpiled.

5.5.2 Ramp Stockpile

Ramp stockpiles, like the one shown in *Figure 13-28*, are constructed to be high with a narrow ramp. This type of stockpile is best for storing a large amount of material in a relatively small area.

Figure 13-28 – Ramp stockpile.

5.5.3 Bin Stockpile

Bin stockpiles, like the one shown in *Figure 13-29*, are constructed within a three-sided enclosure. This enclosure, or bin, usually has a hard floor and walls made of concrete or wood. This type of stockpile is best for keeping various types of material separated.

Figure 13-29 – Bin stockpile.

5.6.0 Backfilling

The front-end loader can also be used to backfill trenches, as shown in *Figure 13-30*. To perform this task, the bucket should be just as wide, or wider, than the loader's wheels or tracks. Narrow buckets can cause the loader to ride up onto the stockpile. This will cause a raise of one corner of the bucket and later require more passes.

Figure 13-30 – Backfilling a trench.

Before backfilling a trench, check the bucket cutting edges for wear. Someone should also direct the operation so that you do not come too close to the edge of the trench.

The steps to backfill a trench are as follows (Please note this technique will not work when pushing a large stockpile. For large stockpiles, work from the edges.):

Step 1. Align the front-end loader with the stockpile (either to the left or the right) while approaching at a 45-degree angle so that one-third of the bucket will contact the stockpile.

Step 2. Adjust the bucket by moving the lift control lever to lower the bucket to just off of the natural ground. If using a multi-purpose bucket, move the bucket control lever to open the bucket to the clam position.

Step 3. Move the front-end loader forward and gradually move the material. Keep the loader in as high a gear as possible without causing the tires to spin excessively.

Step 4. Move the lift control lever to lower or raise the bucket to cut and spread the material the length of the trench.

Step 5. Move the lift control lever to raise the bucket 10 to 14 inches off the ground before reversing direction.

Step 6. Reverse the front-end loader and return to the stockpile.

Step 7. Repeat the above steps until the operation is complete.

5.7.0 Changing Out Attachments

Using the front-end loader quick-disconnect system makes changing out attachments easy. However, ground safety must be established first. Always have a ground guide to direct the operation. When working with quick-disconnect fittings there is the potential of hydraulic fluid spillage. The ground guide should wear personal protection equipment (PPE) such as gloves to protect hands from sharp edges and skin from coming into contact with the hydraulic fluid. The ground guide should also wear safety goggles to protect the eyes from squirting hydraulic fluid. It is also recommended to have a drip pan and rags ready to prevent the fluid from leaking onto the ground.

When you change out an attachment, it should be unloaded, away from traffic, and on a leveled surface.

The following are the steps to change out attachments:

Step 1. Remove attachment by shutting off the front-end loader and relieving hydraulic pressure.

Step 2. Move the hydraulic controls back and forth.

Step 3. Disconnect the hydraulic lines to clam cylinders and reconnect to locking pin lines.

Step 4. Cap unused lines to prevent dirt from entering them.

Step 5. Release locking pins and remove the attachment by starting the front-end loader and pulling the clam lever to release the locking pins.

Step 6. Use the tilt levers to tilt the backing plate all the way forward.

Step 7. Lower the lift arms until the bracket is clear, and back away from attachment.

Step 8. Pick up the attachment by maneuvering the loader to center on the new attachment.

Step 9. Tilt the backing plate all the way forward and lower the boom until the backing plate clears the attachment bracket, and ease up to the attachment.

Step 10. Use tilt lever to roll the backing plate back and pick up the attachment.

Step 11. Push the clam lever to reset the locking pin.

Step 12. Reconnect the attachment by shutting off the front-end loader and releasing the hydraulic pressure.

Step 13. Remove caps or disconnect the clam lines from the locking pins.

Step 14. Reconnect the clam lines to the attachment.

Step 15. Start the front-end loader and charge the attachment hydraulic system.

Step 16. Test the attachment for proper operation.

5.8.0 Clamshell Loading

The front-end loader can remove large and irregular shaped objects with the multi-purpose bucket functioning as a clamshell, as shown in *Figure 13-31*. This configuration offers additional height for dumping. The front-end loader is also better equipped to handle sticky materials.

When loading rocks, remove the smaller and loose rocks first, so that the larger rocks and other solid objects can be loosened and moved more easily.

When loading large rocks into dump trucks, place a load of dirt or sand into the dump bed. The material will act as a cushion and help protect the dump bed from damage. Load into the center of the dump bed from the lowest possible height.

Figure 13-31 – Bucket functioning as a clamshell.

NOTE

When you have extended tasking to haul large rocks or ***riprap***, have the dump beds lined with wooden planking. This will save time loading sand or dirt and also protect the bed.

When transporting trees or other large objects, keep the bucket low for better balance and visibility (*Figure 13-32*). Properly balancing the load will prevent twisting the boom assembly and linkage. When dumping awkward loads, dump slowly to reduce the shock of the weight transferred to the rear axles after the bucket has been emptied.

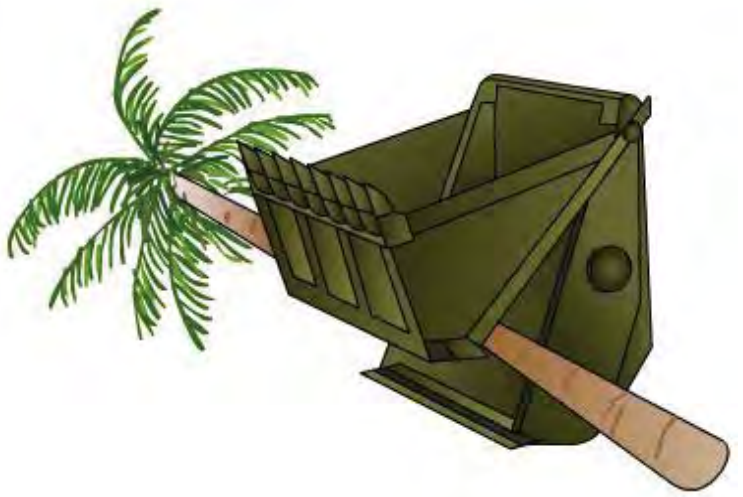


Figure 13-32 – Bucket low and properly balanced.

The steps to load using the multi-purpose bucket as a clamshell are as follows:

Step 1. Center the front of the bucket on the middle of the first load to be picked up. Begin to open the bucket about 5 feet from the load.

Step 2. Move the front-end loader forward and make contact with the load. About two-thirds of the opened bucket should penetrate into the material to be loaded.

Step 3. Close the bucket to secure the load.

Step 4. Position the load 10 to 14 inches above the ground.

Step 5. Maneuver the front-end loader to the desire location.

Step 6. Open the bucket fully.

Step 7. Raise the bucket high enough to clear any previously dumped material. Ensure that all of the material is out of the bucket.

Step 8. Close the bucket.

Step 9. Place the bucket in the travel position (10 to 14 inches above the ground).

Step 10. Repeat the above steps until task is complete.

5.9.0 Finishing

Finishing can be accomplished by back dragging nonsolid materials. Position the bucket as shown in *Figures 13-33* or *13-34*.

Figure 13-33 – Skid shovel finish.

Figure 13-34 – Clamshell finish.

CAUTION

Back dragging abrasive materials causes premature wear to the bucket.

5.10.0 Spreading

By placing the bucket in the scraper position and opening the clamshell slightly, you can spread material on the run. The amount of spread can be controlled by the size of the opening of the clamshell (*Figure 13-35*).

Figure 13-35 – Bucket clamshell positioned for spreading material.

5.11.0 Improper Use of the Multi-Purpose Bucket

You are responsible for the proper use of attachments. Improper use can cause damage to both the attachment and front-end loader. The following are ways a multi-purpose bucket should not be used:

Do NOT use the rollback as a force to pull stumps or buried objects from the ground because this may bend the clamshell (*Figure 13-36*).

Do NOT attempt to break off buried or anchored objects with the clamshell by back dragging because this may bend the clamshell (*Figure 13-37*).

Figure 13-36 – Removing buried objects using the clamshell by rolling back the bucket.

Figure 13-37 – Breaking off an object using the clamshell by back dragging.

Do NOT attempt to break off buried or anchored objects by side loading the clamshell, especially when opened, because this may bend the sides of the clamshell (*Figure 13-38*).

Do NOT clamp objects on only one side of the clamshell because this causes uneven stresses and may twist the clamshell out of alignment (*Figure 13-39*).

Figure 13-38 – Breaking off an object by side loading the clamshell.

Figure 13-39 – Clamping an object on only one side of the clamshell.

Do NOT clamp objects and use them as battering rams because this may bend the clamshell and the cutting edge (*Figure 13-40*).

Do NOT grade in the forward direction with the bucket in the dump position because this can cause damage to the tilt cylinder and linkage (*Figure 13-41*).

Figure 13-40 – Clamping an object and using it as a battering ram.

Figure 13-41 – Grading with the bucket in the dump position.

Do NOT use the bottom of the clamshell as a pile driver because this will bend the clamshell (*Figure 13-42*).

Do NOT attempt to load material in the bucket with an object caught between the clamshell and blade because this could twist the clamshell out of alignment (*Figure 13-43*).

Do NOT attempt to clamshell objects too large to handle because this may damage both the bucket and linkage (*Figure 13-44*).

Figure 13-42 – Using the bottom of the clamshell as a pile driver.

Figure 13-43 – Attempting to load material with an object caught in the clamshell.

Figure 13-44 – Attempting to pickup objects too large for the clamshell.

5.12.0 Operating on Slopes

When operating on slopes, remember that the danger of tipping is always present. Always travel straight up and down slopes, never at an angle or perpendicular to a slope. Have the bucket pointing uphill, as low as possible. If front-end loader starts to slip or becomes unstable, lower bucket to ground and stop the machine immediately.

5.13.0 Crossing Ditches

Cross ditches, ridges, rocks, or logs slowly and at an angle. This will slow the fall, lessen the danger of upsetting the front-end loader, and reduce the jolt of the fall that can cause harm to you and the loader.

Use a uniform system of hand signals in all front-end loader operations. While the authority for giving signals must be assigned to only one person under normal working conditions, the responsibility for giving an emergency stop signal belongs to anyone in the vicinity who believes such a signal is necessary. The person giving the signals must be clearly visible to you at all times.

You must recognize and understand these signals when operating equipment. Additionally, you must also be able to give them when called on to act as a signalman during any equipment operation.

Test your Knowledge (Select the Correct Response)

9. **(True or False)** Front-end loaders are excellent for excavating medium to hard material.

   A. True
   B. False

10. **(True or False)** Excessive wheel and track spinning cause premature wear and tear.

    A. True
    B. False

11. What loading method is recommended for large open areas?

    A. The Y Method
    B. The I Method
    C. The V Method
    D. The S Method

6.0.0 SAFETY

Safety is at the forefront of all operations. You should adhere to the following safety practices when operating a front-end loader:

- Operate wheel front-end loaders carefully because they can easily overturn.
- Use caution when operating close to the edge of a trench or when working under overhangs created by digging into banks or stockpiles.
- Travel with the bucket at or below axle height.
- Ground the bucket and set the parking brake before leaving the machine.

- Block the bucket when working on the machine.
- Do NOT extend any portion of your body between the cab and the lift arms.
- Do NOT work between the wheels and the frame while the engine is running.
- Do NOT carry or lift personnel in the bucket.

Test your Knowledge (Select the Correct Response)

12. **(True or False)** When traveling, the bucket should be at or below axle height.

    A. True
    B. False

Summary

This chapter introduced you to the wheel front-end loader, skid steer and the crawler-mounted front-end loader. You were introduced to their major components, steering and loader controls, and attachments. In addition, you were introduced to operations, such as the “Y” and “I” loading methods. Lastly, you were introduced to practices to adhere to when performing such operations.

Review Questions (Select the Correct Response)

1. **(True or False)** On the wheel front-end loader the pivot point is located in front of the operator's cab.

   A. True
   B. False

2. Which of the following front-end loaders is typically four-wheel drive with the left-side wheel independent of the right side wheels?

   A. Wheel
   B. Skid steer
   C. Crawler-mounted
   D. All of them

3. Which of the following front-end loaders has an oscillating undercarriage that improves traction?

   A. Wheel
   B. Skid steer
   C. Crawler-mounted
   D. All of them

4. The tilt cylinder provides which of the following tilt positions?

   A. Backward and forward
   B. Backward, forward, and hold
   C. Backward, forward, and dump
   D. Backward, forward, and float

5. What prevents articulation when transporting the front-end loader?

   A. Steering cylinder
   B. Steering frame lock
   C. Hydraulic lockout control
   D. Ride control

6. On a front-end loader equipped with a joystick instead of a steering wheel, how would an operator steer left?

   A. Move the joystick right
   B. Pull the joystick backward
   C. Push the joystick forward
   D. Move the joystick left

7. How would an operator move a skid steer forward?

   A. Pull both the left and right steering lever back at the same time
   B. Push both the left and right steering lever forward at the same time
   C. Push the left steering lever forward
   D. Push the right steering lever forward

8. **(True or False)** When the autoshift control is in the centered position, the transmission is in the manual mode.

   A. True
   B. False

9. On the Caterpillar 924G, how would an operator lower the bucket?

   A. Push the lift lever completely forward
   B. Push the lift lever slightly forward
   C. Pull the lift lever completely back
   D. Pull the lift lever slightly back

10. On a front-end loader equipped with a joystick, instead of lift and tilt levers, how would an operator tilt the bucket back?

    A. Push the joystick completely forward
    B. Pull the joystick completely back
    C. Move the joystick to the right
    D. Move the joystick to the left

11. What is the function of the auxiliary hydraulic control lever?

    A. Pressurize the left and right supply lines
    B. Engage the attachment
    C. Disengage the attachment
    D. Act as a shock absorber

12. On the Caterpillar 924G, what limits the bucket tilt angle and lift height?

    A. Bucket/fork selector control
    B. Quick coupler control
    C. Hydraulic lockout control
    D. Kickout and positioner control

13. On the Caterpillar 924G, how would an operator disengage the coupler pins?

    A. Press the bottom half of the quick coupler control
    B. Press the top of the half of the quick coupler control
    C. Push the auxiliary hydraulic control lever forward
    D. Pull the auxiliary hydraulic control lever back

14. **(True or False)** An attachment is not installed properly if there is movement between it and the coupler pins.

    A. True
    B. False

15. The multi-purpose bucket can be used as a _____.

    A. Clamshell, dozer, scraper, and auger
    B. Clamshell, dozer, scraper, and skid shovel
    C. Clamshell, dozer, scraper, and backhoe
    D. Clamshell, dozer, scraper, and forks

16. **(True or False)** Forks can be either attached to the loader's lift arms in place of the bucket or attached to the bucket.

    A. True
    B. False

17. **(True or False)** When loading a bucket from a bank, the operator should keep the cutting edge tilted far back.

    A. True
    B. False

18. What type of stockpile is best for storing a large amount of material in a small area?

    A. Standard stockpile
    B. Ramp stockpile
    C. Bin stockpile
    D. Basic stockpile

19. **(True or False)** To backfill trenches, the bucket should be as wide or wider than the loader's wheels or track.

    A. True
    B. False

20. Which of the following configurations offers additional height for dumping?

    A. Clamshell
    B. Dozer
    C. Scraper
    D. Backhoe

21. Which of the following rocks should be removed first?

    A. Larger rocks
    B. Larger and loose rocks
    C. Smaller rocks
    D. Smaller and loose rocks

22. **(True or False)** When dumping an awkward load, dump slowly to reduce the shock of weight transferred to the rear axles.

    A. True
    B. False

23. **(True or False)** The clamshell can be used as a pile driver.

    A. True
    B. False

24. **(True or False)** The bucket can be used to carry or lift personnel.

    A. True
    B. False

Terms Introduced in this Chapter

Backfill	(1) The material used in refilling a ditch or other excavation. (2) The process of such refilling.
Bank	Specifically, a mass of soil rising above a digging or trucking level. Generally, any soil that is to be dug from its natural position.
Detent	A device for positioning and holding one mechanical part in relation to another in a manner such that the device can be released by force applied to one of the parts.
Engine control module (ECM)	The engine's control computer The ECM provides power to the electronics The ECM monitors data that is input from the engine's sensors The ECM acts as a governor in order to control engine rpm.
Grouser	Projecting lug(s) attached to or integral with the machine track shoes to provide additional traction.
Oscillating	Independent movement through a limited range, usually on a hinge.
Riprap	Heavy stones placed at the edge of the water to protect the soil from waves or current.
Stockpiles	Material dug and piled for future use.
Undercarriage	The undercarriage is an assembly that supports the upper structure of the crane. It consists of an undercarriage frame, a swing bearing, or hook and load rollers, travel mechanism, and steering mechanism. The undercarriage may be either a crawler or wheeled type.

Additional Resources and References

This chapter is intended to present thorough resources for task training. The following reference works are suggested for further study. This is optional material for continued education rather than for task training.

Earthmoving Operations, FM 5-434, Headquarters Department of the Army, Washington, DC, 2000.

Heavy Equipment Operations: Level Two, 2nd ed., National Center for Construction Education and Research, Gainesville, FL and Pearson Education, Inc., Upper Saddle River, NJ, 2006.

Nichols, Herbert L., Jr., *Moving the Earth*, 3rd ed., North Castle Books, Inc., Greenwich, CT, 1985.

924G Wheel Loader; Standard and High Lift Arrangement, Caterpillar, 2005.

Pruess, E. D., *The Rubber Tired Tractor Shovel*, Construction Machinery Division, Clark Equipment Company, Benton Harbor, MI, 1989.

Operation and Maintenance Manual: 924G Wheel Loader, Caterpillar, 2004.

Operator's Manual: 325 Skid Steer, John Deere, OMT205051 Issue F6.

CSFE Nonresident Training Course – User Update

CSFE makes every effort to keep their manuals up-to-date and free of technical errors. We appreciate your help in this process. If you have an idea for improving this manual, or if you find an error, a typographical mistake, or an inaccuracy in CSFE manuals, please write or email us, using this form or a photocopy. Be sure to include the exact chapter number, topic, detailed description, and correction, if applicable. Your input will be brought to the attention of the Technical Review Committee. Thank you for your assistance.

Write: CSFE N7A
3502 Goodspeed St.
Port Hueneme, CA 93130

FAX: 805/982-5508

E-mail: CSFE_NRTC@navy.mil

Rate____ Course Name_____

Revision Date_____ Chapter Number____ Page Number(s)_____

Description

_____

_____

_____

(Optional) Correction

_____

_____

_____

(Optional) Your Name and Address

_____

_____

_____

Chapter 14

Backhoe Loaders

Topics

To hear audio, click on the box. 

Overview

Backhoe loaders are versatile and unique construction equipment. Designed to have two attachments, one at front and the other at the rear, backhoe loaders can excavate trenches and ditches as well as load trucks. In addition, they can perform light duty hoisting.

This chapter provides you the information needed to successfully execute those operations. This chapter describes the types of backhoe loaders used by the Naval Construction Force (NCF). It includes a description of major components, controls, and attachments. In addition, this chapter explains how to perform backhoe operations. Last it lists safety practices.

Objectives

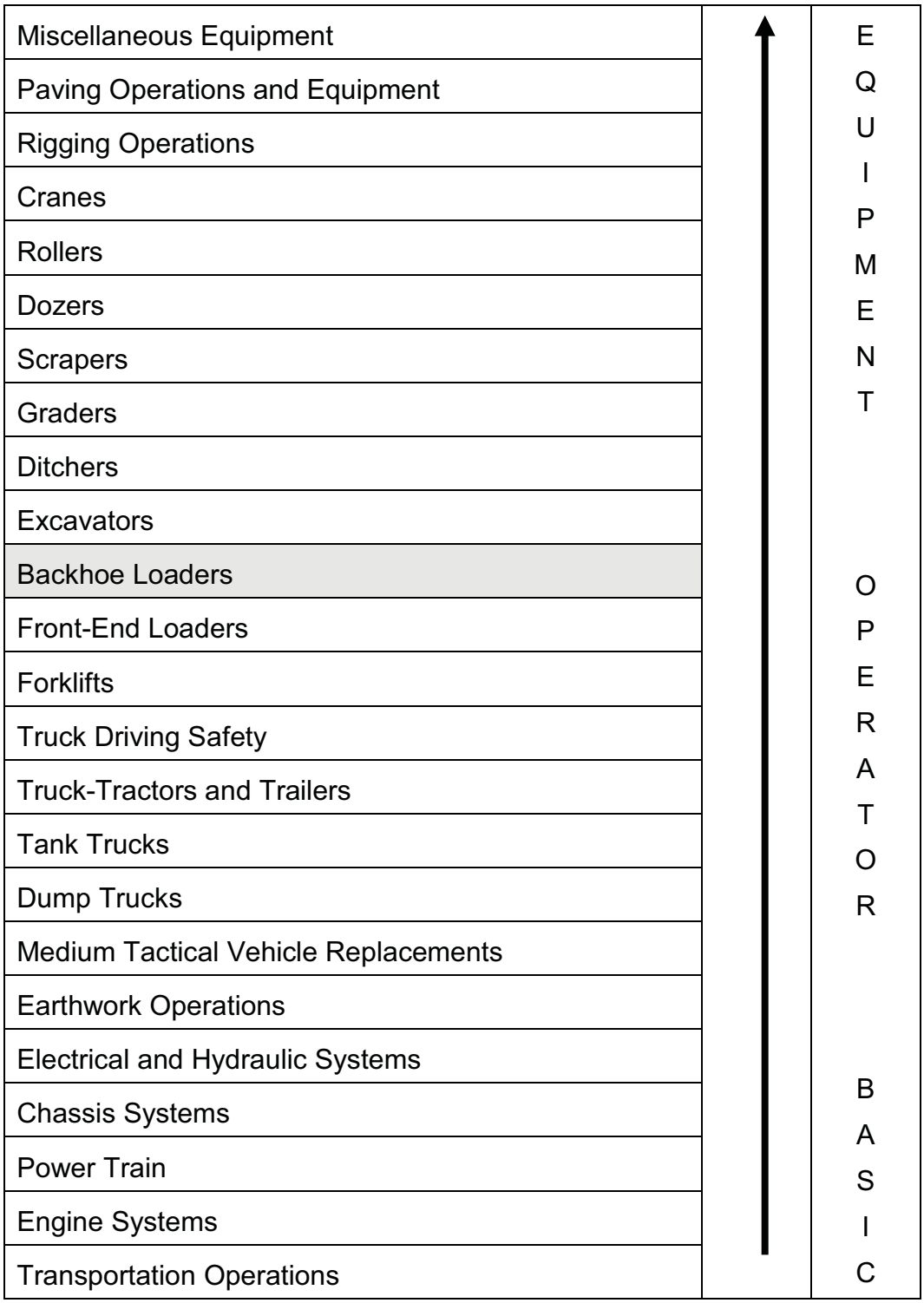
When you have completed this chapter, you will be able to do the following:

1. Understand the use of backhoe loaders.
2. Identify types backhoe loaders used by NCF.
3. Identify the major components of backhoe loaders.
4. Identify the controls on the backhoe loader.
5. Identify backhoe attachments and their use.
6. Understand how to perform backhoe loader operations.
7. Understand backhoe loader safety.

Prerequisites

None

This course map shows all of the chapters in Equipment Operator Basic. The suggested training order begins at the bottom and proceeds up. Skill levels increase as you advance on the course map.



Features of this Manual

This manual has several features which make it easy to use online.

- Figure and table numbers in the text are italicized. The figure or table is either next to or below the text that refers to it.
- The first time a glossary term appears in the text, it is bold and italicized. When your cursor crosses over that word or phrase, a popup box displays with the appropriate definition.
- Audio and video clips are included in the text, with italicized instructions telling you where to click to activate it.
- Review questions that apply to a section are listed under the Test Your Knowledge banner at the end of the section. Select the answer you choose. If the answer is correct, you will be taken to the next section heading. If the answer is incorrect, you will be taken to the area in the chapter where the information is for review. When you have completed your review, select anywhere in that area to return to the review question. Try to answer the question again.
- Review questions are included at the end of this chapter. Select the answer you choose. If the answer is correct, you will be taken to the next question. If the answer is incorrect, you will be taken to the area in the chapter where the information is for review. When you have completed your review, select anywhere in that area to return to the review question. Try to answer the question again.

1.0.0 BACKHOE LOADERS

Backhoe loaders, commonly called backhoes, are unique construction equipment As *Figure 14-1* shows, they are essentially tractors fitted with two attachments, a loader bucket at front for loading trucks and a backhoe at rear for excavating trenches and dumping material to the sides. These attachments can be changed to ammonodate other types, such as forks for handling palletized materials and a compactor for compacting soil after backfilling. The operator's seat can be swiveled around to face either the front or rear attachment and its controls. The design of the backhoe lends itself to be versatile for small- and medium-size jobs.

Figure 14-1 – Backhoe loader.

1.1.0 Types of Backhoe Loaders Used By Naval Construction Force

There are many sizes, models, and configurations of backhoe loaders. Some are crawler-type, mounted on tracks, and others are wheel-type, mounted on rubber tires. The NCF commonly uses wheel-type backhoes.

1.1.1 Wheel-Type Backhoe Loader

Unlike the tracks on the crawler-type backhoe, the rubber tires on the wheel-type backhoe allow it to cross lawns without causing damage. In addition, it can be driven a short distance to and from job sites on public roads.

Test your Knowledge (Select the Correct Response)

1. **(True or False)** Backhoe loaders are tractors fitted with two attachments.

   A. True
   B. False

2. **(True or False)** The design of backhoe loaders allows for medium-to-large size construction jobs.

   A. True
   B. False

2.0.0 MAJOR COMPONENTS

Major components and controls on backhoe loaders vary among makes and models. You are responsible for reading the operator's manual for specific information. *Figure 14-2* shows the major components of a Caterpillar 420 wheel-type backhoe loaders.

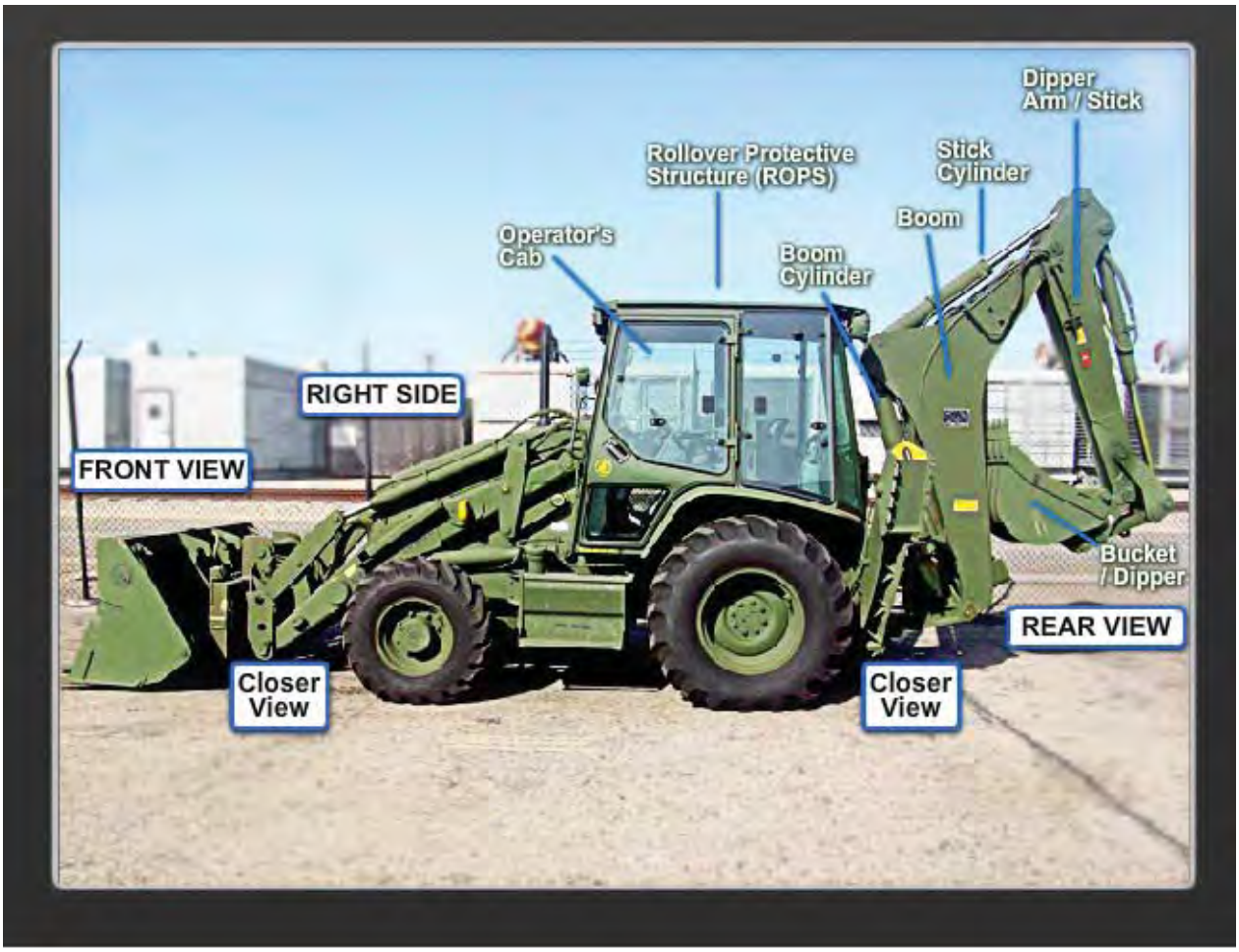


Figure 14-2 – Major components.

2.1.0 Operator's Cab

The operator's cab is the central location of most instruments and controls. It is fully enclosed by a rollover protective structure. This provides protection against harsh weather for the operator, instruments and controls.

By use of a swivel seat, the backhoe loader can operated from two positions, forward and back. Forward position is facing towards the loader bucket. In this position the operator has easy access to the bucket controls as well as to an instrument panel and controls such as a steering wheel, governor control, and service brakes. These controls are responsible for moving and positioning the machine.

Back position is facing towards the backhoe attachment. In this position the operator has access to the backhoe controls and has an undisturbed view of the boom. On the operator's left side is another instrument panel used to operate the backhoe. *Figure 14-3* shows both instrument panels on a Caterpillar 420D.

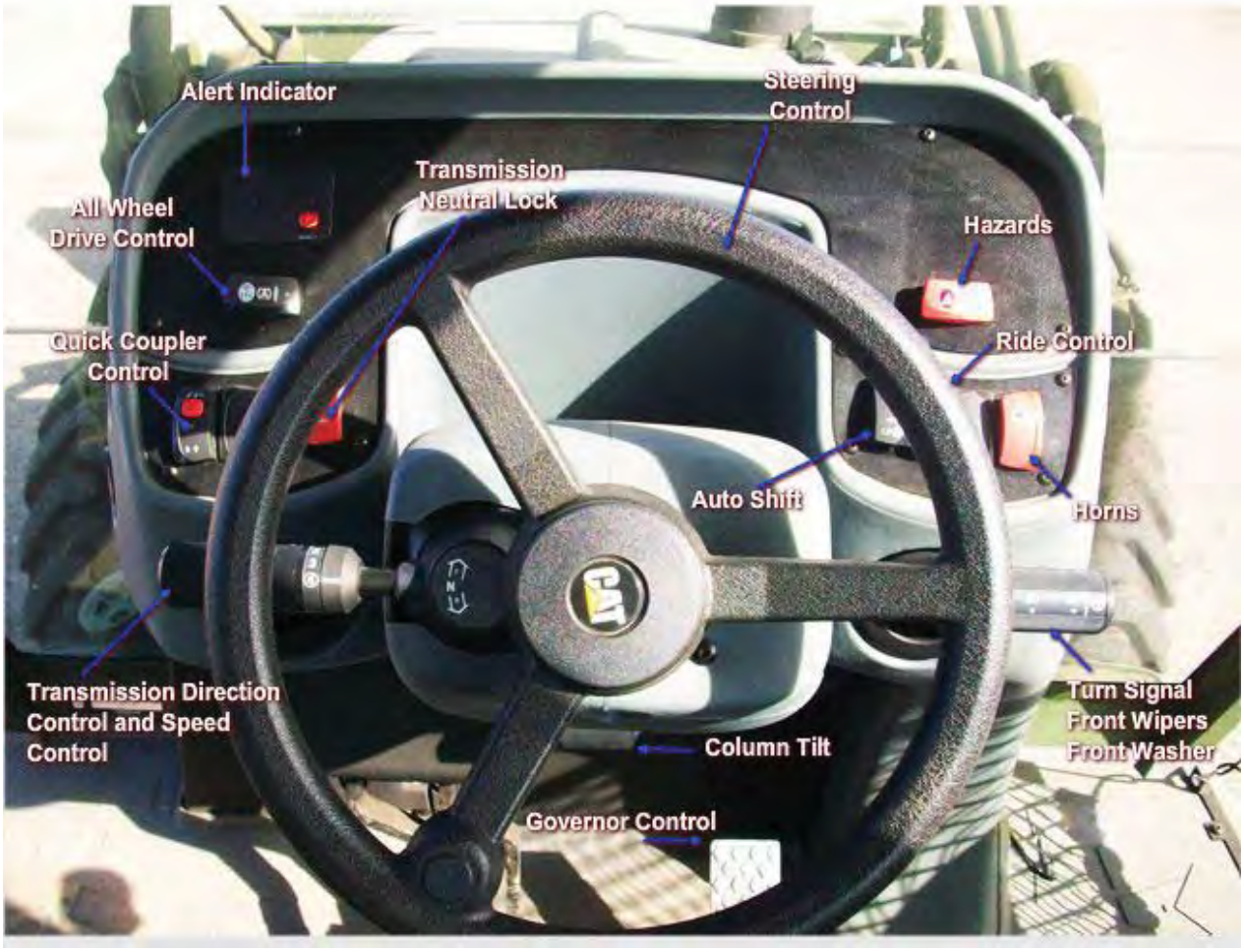


Figure 14-3 – Instrument panels.

Beyond the typical controls found on construction equipment, backhoes are equipped with ride control, a feature that reduces the forward and backward pitching motion when traveling, provides a smooth and stable ride for operator's comfort, and improves material retention in the loader bucket for increased productivity and a cleaner job site.

In addition, the backhoe is equipped with a foot-operated differential lock control, as shown earlier in *Figure 14-3*. Located near the service brakes, this control locks in the rear differential on both wheels, preventing wheel spillage when moving on soft or muddy surfaces.

2.2.0 Rollover Protective Structure

The rollover protective structure (ROPS) is a removable bolt-on frame that provides the operator a safe environment in the event of a rollover.

2.3.0 Loader Tilt Cylinders

The loader tilt cylinders control the tilt angle of the loader bucket. By moving a joystick located in the operator's cab, the operator can extend or retract these cylinders to the desired tilt angle. They provide two tilt positions: dump and tilt back.

2.4.0 Loader Lift Cylinders and Arms

The loader lift cylinders and arms control the lift of the loader bucket. By moving a joystick located in the operator's cab, the cylinders are extended and retracted to the desired lift angle. They provide four lift positions: lift, lower, hold, and raise. *Figure 14-4* shows loading and excavation motion for a backhoe loader.

Figure 14-4 – Range of motion.

2.5.0 Loader Bucket

Similar to the bucket on a front-end loader, the loader bucket is used to load and dump material. Backhoe loaders also have quick coupler that allows for quick connection to selected attachments.

2.6.0 Stabilizers/Outriggers

Because of their intrinsically top-heavy design and the swinging weight of the backhoe attachment, backhoe loaders can easily tip over. For this reason, they have stabilizers, also called outriggers, located behind each of the rear wheels. Hydraulically controlled, to raise and lower, the stabilizers provide stability, minimize jolting, and reduce strain on the wheels by taking the brunt of the weight when the backhoe is digging. They also

secure the backhoe from slipping into the trench or ditch. While in the cab, checking that no one is in the path, the operator can raise and lower the left and right stabilizer.

Stabilizers like the ones featured earlier in *Figure 14-2* are used when operating on soil; however, on asphalt, they sink and they destroy concrete. Therefore, stabilizers can be fitted with replaceable street pads consisting of rubber soles when operating on streets or other paved surfaces, as shown in *Figure 14-5*.

Figure 14-5 – Street pad.

2.7.0 Excavating Arm

The excavating arm on the backhoe loader is comparable to your arm consisting of an upper arm, forearm, and hand. It consists of a boom, dipper arm/stick, and bucket/dipper. All three of these components can be hydraulically operated by two backhoe joysticks.

2.7.1 Boom

A hydraulic cylinder controls the rising or lowering of the boom. The top of the boom is curved outwards to make it easier to dig with obstacles in the way. This design also provides extra space for the bucket to curl in with a full load. The boom is also narrow, enhancing the view of the bucket and excavation.

Swing cylinders control the left and right movement of the boom. They allow the boom to swing 205 degrees in order to dump materials to the side after each dig.

NOTE

When roading or transporting the backhoe or when using the loader bucket, the operator can use a swing lock pin which is installed to prevent the boom from swinging. In addition, the boom lock lever, shown earlier in *Figure 14-3*, locks the boom in the retracted position when it is not in use.

2.7.2 Dipper Arm/Stick

A stick cylinder controls the in and out movement of the dipper arm/stick. It allows the dipper arm to reach and crawl during excavation.

2.7.3 Bucket/Dipper

Another cylinder controls the closing and dumping of the bucket/dipper. Often equipped with wider teeth, the bucket/dipper is also much narrower than the loader bucket, making it an excellent tool for excavating narrow trenches and tight areas. This comparison is shown in *Figure 14-6.*

Figure 14-6 – Buckets.

The bucket/dipper can be adjusted for two positions. The position for loading is shown in *Figure 14-7.* The position for digging deep vertical holes is shown in *Figure 14-8.*

Figure 14-7 – Position for loading trucks.

Figure 14-8 – Position for digging deep vertical holes.

Test your Knowledge (Select the Correct Response)

3. **(True or False)** In the forward position, the operator has access to the backhoe controls and an undisturbed view of the boom.

   A. True
   B. False

4. To steer, a typical backhoe loader has _____.

   A. A joystick
   B. A steering lever
   C. A steering wheel
   D. Foot pedals

3.0.0 CONTROLS

Backhoe operations involve the use of the following controls: two backhoe joysticks, a backhoe auxiliary control, stabilizer levers, and a loader joystick.

To operate the hydraulic controls, like the backhoe and loader joysticks, the operator must press the bottom half of the hydraulic lock switch, shown earlier in *Figure 14-3*. The hydraulic lock switch prevents movement of the joysticks when the backhoe is transported.

3.1.0 Backhoe Joysticks

When seated in the operator's seat facing the backhoe, the operator has use of two joysticks. *Figure 14-9* shows both the left- and right-hand backhoe joysticks on a Caterpillar 420D. By operating these joysticks, the operator can move the dipper arm in, out, left, and right, raise and lower the boom, and dump and close the bucket.

Each joystick has five positions: forward, back, left, right, and center. Although each joystick controls specific movement, when a joystick is in the center position such movement is suspended. In addition, when you release either joystick, it will return to the center position.

Figure 14-9 – Backhoe joysticks.

3.1.1 Left-Hand Backhoe Joystick

Use the left-hand backhoe joystick to move the dipper arm in, out, left, and right.

- To move the dipper arm out, push the left-hand joystick forward.
- To move the dipper arm in, pull the joystick back.
- To swing the dipper arm right, move the joystick right.
- To swing the dipper arm left, move the joystick left.

3.1.2 Right-Hand Backhoe Joystick

Use the right-hand backhoe joystick to lower and raise the boom, and to dump and close the bucket.

- To lower the boom, push the right-hand joystick forward.
- To raise the boom, pull the joystick back.
- To close the bucket, move the joystick left.
- To dump the bucket, move the joystick right.

You can perform two functions at the same time by moving the joysticks diagonally.

Figure 14-10 allows you to operate both the left and right backhoe joysticks.

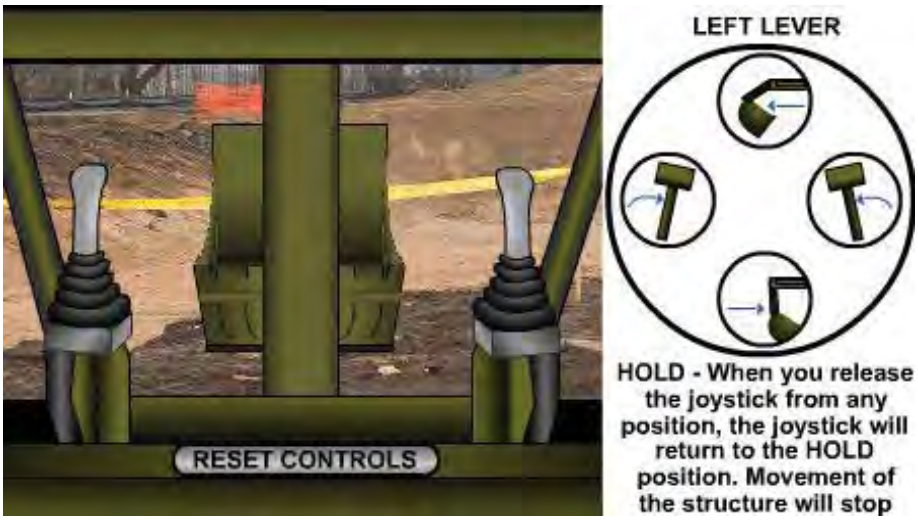


Figure 14-10 – Operating backhoe joysticks.

WARNING

Always refer to operator's manual for proper control pattern before operating. Failure to understand control function could result in injury or death.

3.2.0 Backhoe Auxiliary Control

As shown in *Figure 14-11*, the backhoe auxiliary control is foot operated. Use the auxiliary pedal to pressurize the hydraulic line of the rear attachment.

- To pressurize the hydraulic line on the right side of the stick, press down on the toe end of the backhoe auxiliary control.
- To pressurize the hydraulic line on the left side of the stick, press down on the heel end.
- When the control is released from any position, the control will return to the hold position.

Figure 14-11 – Backhoe auxiliary control.

3.3.0 Stabilizer Levers

The stabilizers are controlled by two levers located on the left hand side of the operator when seated and facing the backhoe, as shown in *Figure 14-12*. The lever closer to the instrument panel controls the left stabilizer. The one closer to the operator controls the right stabilizer. Each lever has four positions: forward, center, slightly back, and completely back. By moving these levers, the operator can lower, raise, hold the stabilizers, or put the stabilizers in auto up mode.

Figure 14-12 – Stabilizer levers.

- To lower either the left or right stabilizer, push its corresponding lever forward.
- When either lever is released, it will turn to the center position, whereupon the movement of the stabilizer will stop.
- To raise either stabilizer, slightly pull its corresponding lever back.
- To automatically raise a stabilizer, completely pull its lever back. The lever will remain in the position for 10 seconds.

WARNING

Be careful when raising the stabilizers. The stabilizers can be the only restraint that is preventing the backhoe loader from falling into the area that is being excavated. When operating on a slope, engage the parking brake before raising the stabilizers.

When swinging the backhoe to either side, fully raise the stabilizer or fully lower the stabilizer to prevent the backhoe from hitting the stabilizer.

3.4.0 Loader Joystick

When sitting in the operator's seat, the operator has use of one loader joystick. *Figure 14-13* shows the configuration of the loader joystick on a Caterpillar 420D. By operating this joystick, the operator can lower, float, hold, raise, tilt back, and dump the loader bucket.

The loader joystick has six positions: slightly and completely forward, center, back, left, and right. Like the backhoe joysticks, when the loader joystick is in the center position, the movement of bucket is suspended. In addition, when you release the joystick, it will return to the center position.

Figure 14-13 – Loader joystick.

- To lower the loader bucket, slightly push the loader joystick forward.
- To float the bucket along the contour of the ground, completely push the joystick forward. Do not use this position to lower the loader bucket. The joystick will stay in the float position until you move it back to the center position or to another position.
- To raise the loader bucket, pull the joystick back.
- To tilt the bucket back, move the joystick left.
- To tilt the bucket forward to dump, move the joystick right.

Figure 14-14 allows you to operate the loader joystick.

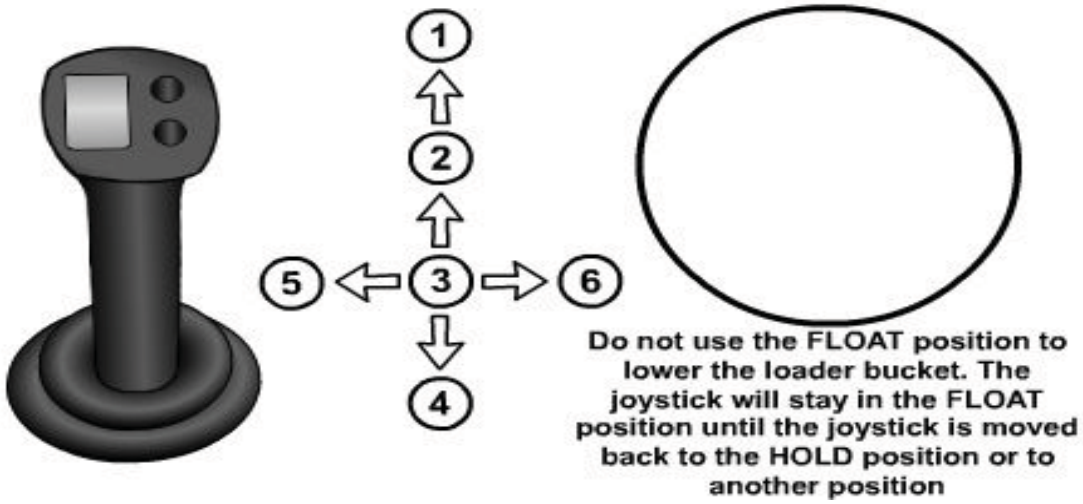


Figure 14-14 – Operating loader joystick.

When attached, the clamshell bucket is operated by a three-position switch on the loader joystick. To open the clam, press the top half of this switch. To close the clam, press the bottom half. To stop the movement of the clam, release the switch and it will return to the hold position.

To operate other types of attachments, use the multi-purpose buttons and the same three-position switch. The buttons activate an electrical connection on the front of the backhoe loader. When you press the top half of the switch, the right-side hydraulic line is pressurized. When you press the bottom half, the left-side hydraulic line is pressurized. When neither half is pressed, the hydraulic lines are off.

Test your Knowledge (Select the Correct Response)

5. On the Caterpillar 420D, what control moves the dipper arm out and in?

   A. Right-hand backhoe joystick
   B. Left-hand backhoe joystick
   C. Dipper arm lever
   D. Loader joystick

6. **(True or False)** On the Caterpillar 420D, the stabilizer lever closest to the instrument panel controls the right stabilizer.

   A. True
   B. False

4.0.0 ATTACHMENTS

There are several attachments to use with the backhoe loader. These attachments serve different purposes. Before using any attachment, read the manufacturer's instructions for the specific backhoe and attachment to ensure compatibility.

4.1.0 Buckets

As with front-end loaders, several types of buckets can be attached to backhoe loaders. The most commonly used buckets are the general-purpose bucket and multi-purpose bucket. These buckets have unique usage and loading capacities.

4.1.1 General-Purpose Bucket

The general-purpose bucket is a single-piece bucket constructed of heavy duty, all-welded steel with bolted or welded replaceable cutting edges, as shown in *Figure 14-15*. Also attached are bolt-on replaceable teeth, shown in *Figure 14-16*, that allow the bucket to be used for excavation of medium-to-hard materials.

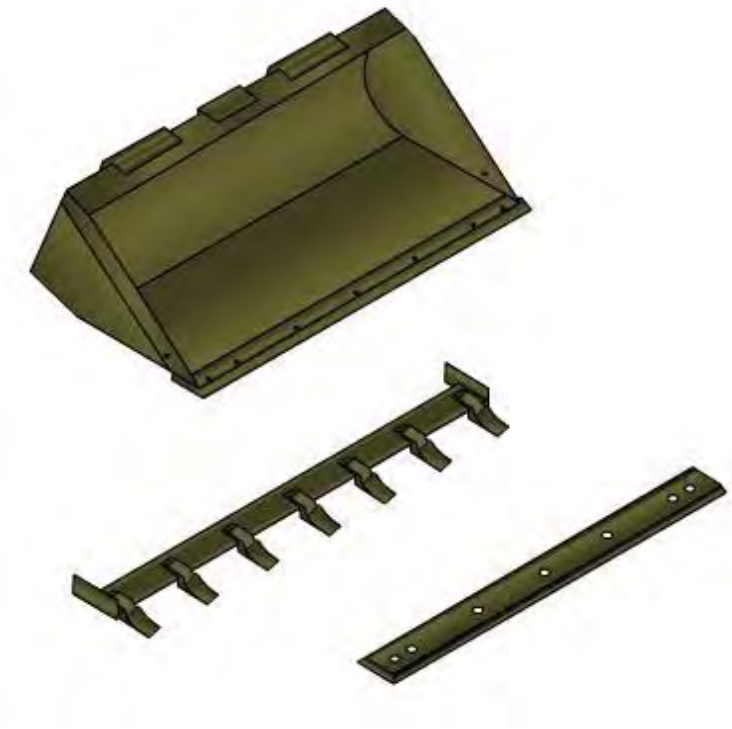


Figure 14-15 – General-purpose bucket.

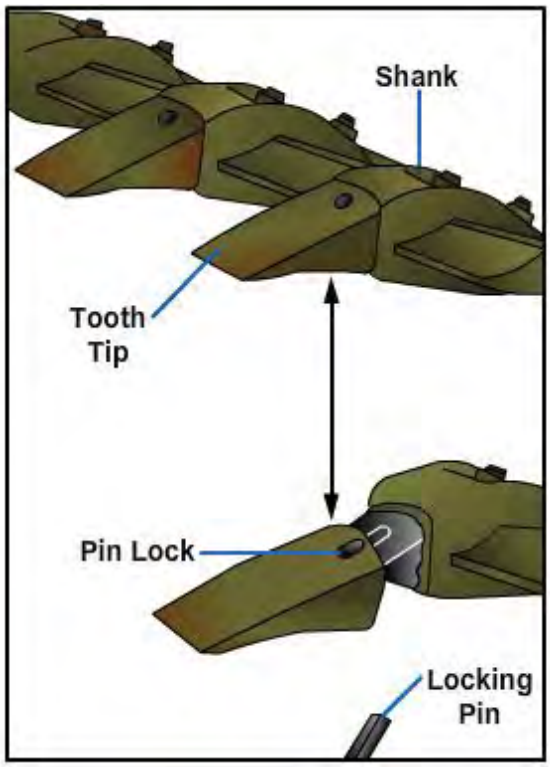


Figure 14-16 – Bucket teeth.

4.1.2 Multi-Purpose Bucket

Like the general-purpose bucket, the multi-purpose bucket, also known as the four-in-one bucket, is constructed of heavy duty, all-welded steel with bolted or welded replaceable cutting edges, as shown in *Figure 14-17*. This bucket also has bolt-on replaceable teeth attached that provide for excavation of medium-to-hard materials

Unlike the general-purpose bucket, the multi-purpose bucket has a two-piece construction that makes it more versatile than the general-purpose single-piece bucket. With the use of auxiliary hydraulic lines, the multi-purpose bucket can be used as a clamshell for grabbing material, a dozer for pushing material, and a scraper or skid shovel for finishing or spreading material.

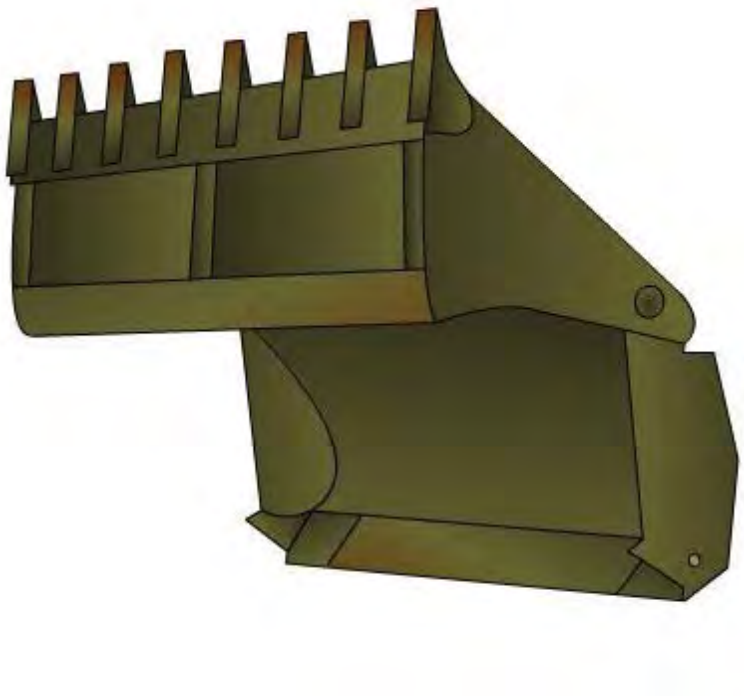


Figure 14-17 – Multi-purpose bucket.

4.2.0 Forks

The forks are useful tools at remote project sites (*Figure 14-18*). They are made of heavy duty steel with two movable tines used for handling palletized material. They can be attached to the loader lift arms in place of the bucket or attached to the bucket, as shown in *Figure 14-19.*

When using the forks, take care not to overload the loader.

Figure 14-18 – Forks.

Figure 14-19 – Forks attached to loader bucket.

4.3.0 Compactors

After backfilling trenches or excavated areas, the compactor attachment is used to compact the soil to specified finishing standards. The NCF commonly uses the vibratory plate compactor, like the one shown in *Figure 14-20*. Such a compactor is available in various sizes and is attached to the end of the dipper arm/stick.

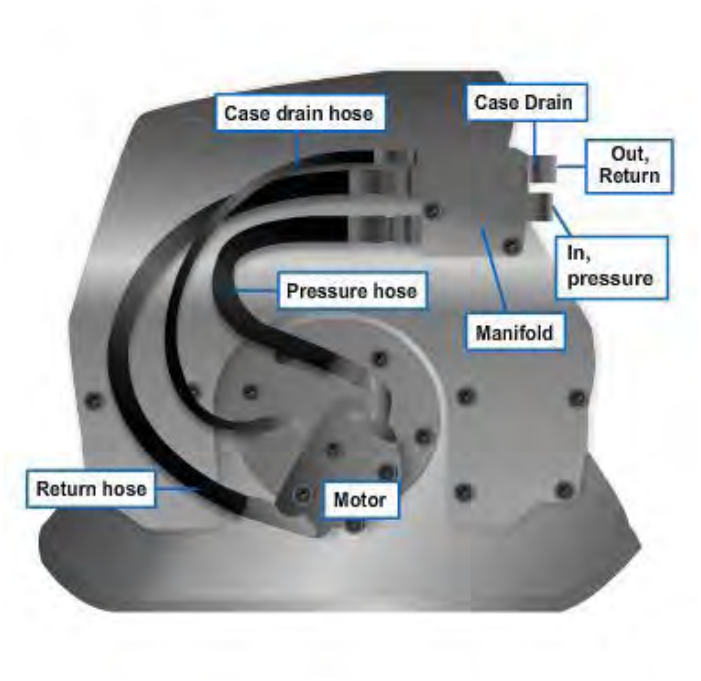


Figure 14-20 – Vibratory plate compactor.

Test your Knowledge (Select the Correct Response)

7. Which of the following buckets has a single-piece construction?

   A. General-purpose bucket
   B. Multi-purpose bucket
   C. Rock bucket
   D. Blast bucket

8. **(True or False)** A compactor is used to compact soil to specific finishing standards.

   A. True
   B. False

5.0.0 OPERATIONS

When operated according to their specific operator's manual, backhoes are safe. However, when operated incorrectly, backhoes can be potentially dangerous. As an operator, you are responsible for reading and understanding the operator's manual.

The operation of the loader bucket on a backhoe loader is similar, if not identical, to that on a front-end loader; therefore, for more information about bucket loading, stockpiling, and backfilling, refer to Equipment Operator Basic, Chapter 13 Front-End Loaders. The following section describes the work activities of the backhoe attachment.

5.1.0 Trenching and Loading

The backhoe is the perfect machine to excavate narrow trenches like the one shown in *Figure 14-21*.

Figure 14-21 – Trenching.

Provided below are the steps for trenching and loading a dump truck. When performing these steps, remember that the backhoe can dig more material in less time when a smooth, short dig cycle is used. When the bucket is forced to excavate a load that is too large (when the dipper stick control lever is pulled back and the bucket is not moving), a "hydraulic stall" results in the loader hydraulic system. When this occurs, the main relief valve of the hydraulic system makes a noise, alerting the operator to release the control levers.

⚠ CAUTION ⚠

Hydraulic stalls cause the temperature of the hydraulic fluid to increase, which can cause premature wear to the hydraulic system.

Step 1. Position the backhoe in a straight line from the trench.

Step 2. Position the dump truck so that the backhoe loads down the center of the dump bed, as shown in *Figure 14-22*.

Figure 14-22 – Position of dump bed for loading.

Step 3. Lower the loader bucket and the left and right stabilizers to the ground. This position provides stability.

Step 4. Engage the dipper arm/stick to move the bucket to about 75 percent of the maximum reach.

Step 5. Engage the bucket so that it cuts at a 30-degree angle to the ground. Digging should be done at a slight angle off the vertical to decrease teeth wear.

Step 6. Move the boom to lower the bucket to the ground.

Step 7. Engage the dipper arm/stick to move in, and as the bucket enters the material, manipulate the bucket so that the cutting edge is working parallel to the ground. Avoiding forcing the bucket too close to the ground. This could damage the hydraulics and reduce digging efficiency.

Step 8. Raise or lower the boom slightly if the dipper arm/stick slows or stops filling the bucket.

Step 9. When it is full, raise the bucket. Remember that full buckets are more efficient and fast than half-full buckets. *Figure 14-23* shows the proper way of filling a bucket.

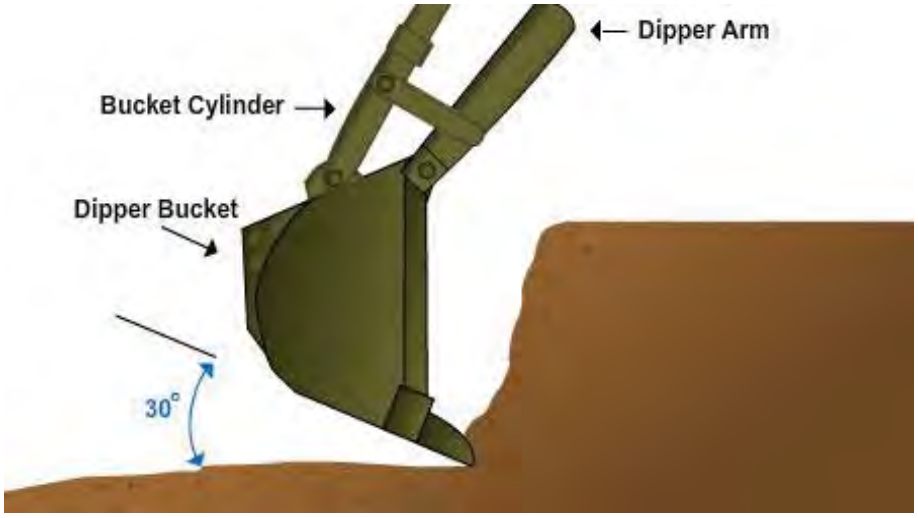


Figure 14-23 – Filling the bucket.

Step 10. Raise the boom to clear the cut and side of the truck.

Step 11. Swing the dipper arm/stick over the dump bed.

Step 12. Slowly dump the bucket. Remember to load the truck from the end closest to the cab to the rear of the truck.

Step 13. Swing the dipper arm/stick back to the cut and continue the procedure until the trench is completed or until the dump truck is fully loaded.

5.2.0 Setting Pipe

After the excavation of a trench, a backhoe can be used to set pipe. This operation involves placing bedding material from a nearby stockpile into the trench and lifting and placing the pipe to rest on it. Provided below are the steps for setting pipe.

5.2.1 Placing Bedding Material

Step 1. Fill the bucket/dipper with the bedding material.

Step 2. Move the bucket into the ditch and position it off the bottom so the bucket will clear the bottom of the ditch when it is uncurled.

Step 3. Cast out the bucket to spread the material.

Step 4. Drag the bucket with teeth down through the trench to help level out material and maintain grade.

Step 5. Remove the bucket from the trench and fill it with more material.

Step 6. Repeat these steps until the bedding material is placed and leveled.

5.2.2 Lifting and Placing Pipe

Before lifting and placing a pipe section into position, become familiar with the use of rigging devices such as slings and shackles, which are featured in Chapter 22 Rigging Operations.

Step 1. Connect the rigging device to the shackle on the back of the bucket/dipper, as shown in *Figure 14-24.*

Figure 14-24 – Rigging a sling to the bucket.

Step 2. Lower the boom and center it over the pipe so that the rigging device can be attached.

Step 3. Raise the boom so that the slack is taken out of the rigging device.

Step 4. Continue to raise the boom until the pipe clears all obstructions. Ensure not to hit any shoring that is erected in the trench.

Step 5. Lower the pipe so that it will line up with the end of the pipe section previously placed.

5.3.0 Excavating Foundations

The backhoe loading can also be used to excavate footings and foundations for buildings. Because of its size, compared to an excavator the backhoe is the best choice for smaller excavations and tight areas.

When the backhoe is used for the digging of square- or rectangular-shaped jobs, the procedures may vary with the shape of the job, restrictions caused by surrounding buildings, or special requirements for disposal of the spoil. In all cases, plan the starting point and digging sequence so that the backhoe conveniently works itself out into the clear. Improper procedures will not only trap the machine, but can also lead to situations where the machine cannot be positioned to complete the job. In this situation, hand digging may be required to complete the excavation.

An accepted starting and digging sequence that can be followed for excavating a small foundation is shown in *Figure14-25*. Remember that digging time is lost each time the machine must be moved. Plan the digging sequence so that a maximum amount of spoil can be excavated before the machine is moved to the next position.

For example, in *Figure 14-25*, make the first cut on the west line. The starting position of the machine should be on the west line at a point where the boom and dipper stick will reach the northwest corner. Line up the machine and boom parallel with the west cutting line so that the outer edge of the bucket is exactly in line with the cutting line.

Make the first cut by digging a ditch along the west cutting line. Dig the ditch to its full depth and grade. This depth and grade serve as a depth guide for the other cuts. When you have dug the west wall as close as possible to the machine position, then swing the boom to reach near the center of the north cutting line. Make the second cut, also shown in *Figure 14-25*, by digging a trench back from the north wall. Move the material cut in the angle formed between these two trenches in layers until the bottom grade is reached.

NOTE

Ensure that the desired grade is reached before moving the backhoe.

Then back up the backhoe into the second position, as shown in *Figure 14-25*. Continue digging in the steps shown in *Figure 14-25*. Dig the ditch first along the west line. Then swing the boom around to cut the angle trench and move the material to grade. Continue digging in this manner until the south line is reached.

Then move the backhoe to the unexcavated portion of the south line. This position is shown in *Figure 14-25*. Here, position the backhoe with the bucket in the excavation at the southwest corner to begin the ditch along the south cutting line. Again, after the ditch is dug along the cutting line, swing the boom toward the center to remove as much spoil as possible from this machine position. Continue to move the backhoe around the excavation, repeating the digging steps until all four cutting lines are cut and the spoil removed. To make the final cut to remove the material, you may have to position the machine at the edge so the bucket can dig straight up. This cannot be done unless the soil type is known to have good bearing qualities. Cave-ins will result if the soil will not support the weight of the machine.

NOTE

Before excavating at a jobsite, always consult with the project supervisor or crew leader about your excavation plans. Keep in mind that the area where you might be placing the

spoil material might be an area for other construction tasking. Excavating at a jobsite must be a well thought-out plan.

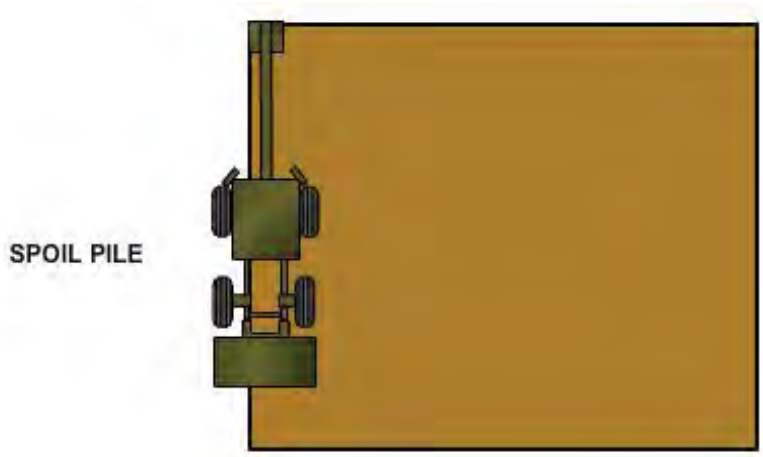


Figure 14-25 – Foundation excavation.

5.4.0 Excavating Between Objects

When excavating between two objects that do not provide enough room to position the backhoe straight ahead, excavate with the boom in full swing position. Position the backhoe to the side of the excavation so that the boom is parallel to the excavation, as shown in *Figure 14-26*.

Figure 14-26 – Position to excavate between objects.

Provided below are the steps for digging between objects.

Step 1. Center the backhoe loader over the trench. Lower the left and right stabilizer.

Step 2. Excavate in the maximum swing position.

Step 3. Dump the load behind the excavation.

Step 4. Move the backhoe if necessary to excavate the opposition side.

Step 5. Move the backhoe back and perpendicular to the excavation, as shown in *Figure 14-27*, to excavate a larger area to connect the excavation.

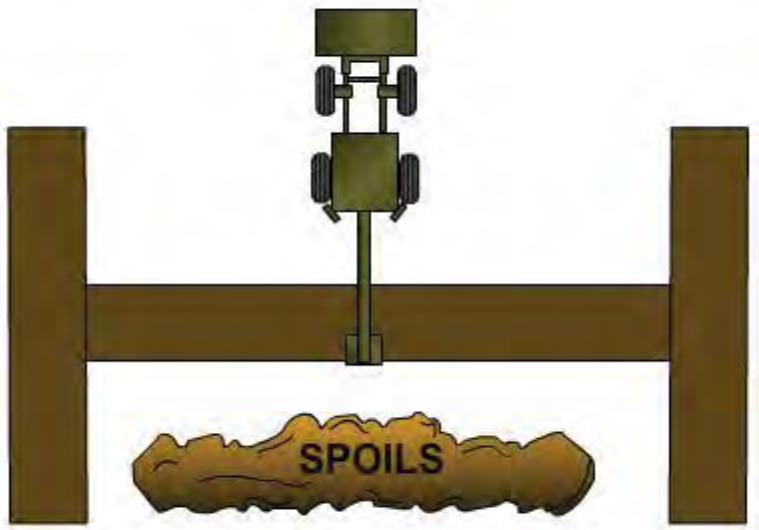


Figure 14-27 – Connecting the excavation.

Test your Knowledge (Select the Correct Response)

9. **(True or False)** The backhoe loader digs more material in less time when a smooth, long dig cycle is used.

   A. True
   B. False

10. **(True or False)** When starting to cut a trench, always position the tractor in a straight line from the trench.

    A. True
    B. False

6.0.0 SAFETY

Safety precautions that apply when you operate backhoes loaders are as follows:

- Clear the immediate area of personnel or obstructions before starting the engine.
- Keep the bucket as close to ground level as possible when transporting loads on grades or slopes.
- Never operate any control from any position except when you are sitting in the operator's seat. When operating the loader bucket, you must face the forward position. When operating the backhoe, you must face the back position.
- Be extra careful when working on banks or hillsides.

- Always keep the machine in gear when going down steep grades. Never coast or freewheel.
- Drive at speeds slow enough to ensure safety and complete control, especially over rough terrain.
- Reduce speed when making turns or applying brakes.
- Always lower the lift arms or boom to the ground or block them securely before performing any service or when leaving the machine unattended.
- Never dismount the backhoe when it is in motion.
- Never permit anyone to ride on the equipment.
- Do NOT oil, lubricate, or make adjustments when the engine is running or the bucket is raised and unblocked.
- Never refuel when the engine is running.
- Do NOT smoke when refueling.
- Never operate in a closed area; provide proper ventilation.
- Do NOT wear loose-fitting clothing which may catch in moving parts.
- Always wear seat belts, steel-toe safety shoes, hard hats, gloves, and other required personal protective equipment.

Test your Knowledge (Select the Correct Response)

11. **(True or False)** It is a safe practice to reduce speed when turning or apply brakes.

    A. True
    B. False

Summary

The backhoe loader is a versatile piece of equipment. Not only can it perform the same operations as a front-end loader, it can also excavate trenches and ditches. This chapter introduced you to the Caterpillar 420D wheel-type backhoe loader commonly used by the NCF. You were introduced to its major components, such as its boom, dipper arm, and bucket/dipper as well as to their respective controls. You were introduced to the compactor attachment, which is unique to backhoe loader and operations such as trenching and setting pipe, operations that both involve lowering the stabilizers for greater stability. Last, you were introduced to safety practices to adhere to when performing such operations.

Review Questions (Select the Correct Response)

1. **(True or False)** The wheel-type backhoe can be driven on public roads.

   A. True
   B. False

2. Which of the following is NOT a function of ride control?

   A. To provide a smooth and stable ride
   B. To reduce pitch motion
   C. To prevent wheel slippage
   D. To improve material retention

3. What backhoe component provides stability, minimize jolting, and reduce strain on the wheels when digging?

   A. Ride control
   B. Stabilizers
   C. Differentials
   D. Boom

4. **(True or False)** When operating on paved surfaces, the stabilizers are fitted with street pads.

   A. True
   B. False

5. While the backhoe is being transported, what prevents the boom from moving left and right?

   A. Swing cylinders
   B. Swing lock pin
   C. Boom lock
   D. Hydraulic lock switch

6. What component of the backhoe reaches and crawls during excavation?

   A. Boom
   B. Bucket
   C. Dipper arm
   D. Stabilizer

7. On the Caterpillar 420D, how would an operator lower the boom?

   A. Push the left-hand backhoe joystick forward.
   B. Pull the left-hand backhoe joystick back.
   C. Push the right-hand backhoe joystick forward.
   D. Pull the right-hand backhoe joystick back.

8. On the Caterpillar 420D, how would an operator dump the bucket/dipper?

   A. Move the left-hand backhoe joystick left.
   B. Move the left-hand backhoe joystick right.
   C. Move the right-hand backhoe joystick left.
   D. Move the right-hand backhoe joystick right.

9. On the Caterpillar 420D, how would an operator pressure the hydraulic line on the right side of the stick?

   A. Press down on the toe end of the backhoe auxiliary control.
   B. Press down on the heel end of the backhoe auxiliary control.
   C. Move the backhoe auxiliary control left.
   D. Move the backhoe auxiliary control right.

10. When operating on a slope, engage the _____ before raising the stabilizers.

   A. parking brake
   B. service brake
   C. emergency brake
   D. differential

11. On the Caterpillar 420D, how would an operator raise the loader bucket?

   A. Push the loader joystick forward.
   B. Pull the loader joystick back.
   C. Move the loader joystick left.
   D. Move the loader joystick right.

12. On the Caterpillar 420D, how would an operator tilt the loader bucket back?

   A. Push the loader joystick forward.
   B. Pull the loader joystick back.
   C. Move the loader joystick left.
   D. Move the loader joystick right.

13. **(True or False)** To stop the movement of the loader bucket, move the joystick to the far back.

   A. True
   B. False

14. Which of the following buckets has bolt-on replaceable teeth that allow it to excavate medium-to-hard materials?

   A. General-purpose bucket
   B. Multi-purpose bucket
   C. Rock bucket
   D. Blast bucket

15. Which of the following buckets can be used as a clamshell, dozer, scraper and skid shovel?

    A. General-purpose bucket
    B. Multi-purpose bucket
    C. Rock bucket
    D. Blast bucket

16. **(True or False)** A “hydraulic stall” results in the loader hydraulic system when the bucket is forced to excavate a load that is too large.

    A. True
    B. False

17. **(True or False)** Before lifting and placing a pipe section into position, the operator should be familiar with the use of rigging devices such as slings and shackles.

    A. True
    B. False

18. Where is the shackle located on the bucket/dipper?

    A. On front of the bucket
    B. On back of the bucket
    C. Under the bucket
    D. Right above the bucket

19. **(True or False)** Digging time is gained each time the backhoe is moved.

    A. True
    B. False

20. How would an operator excavate between two objects with little room?

    A. With the boom in half swing position
    B. With the boom in full swing position
    C. With the backhoe straight ahead of the excavation
    D. With the backhoe on the perpendicular end of the excavation

21. **(True or False)** It is a safe practice to operate the loader bucket while seated facing the backhoe.

    A. True
    B. False

22. **(True or False)** It is a safe practice to dismount the backhoe when it is in motion.

    A. True
    B. False

Additional Resources and References

This chapter is intended to present thorough resources for task training. The following reference works are suggested for further study. This is optional material for continued education rather than for task training.

Case, 480E Loader Backhoe, Operator's Manual, J. I. Case Company, 2525 West Hampton Avenue, Milwaukee, WI, 1986.

Earthmoving Operations, FM 5-434, Headquarters Department of the Army, Washington, DC, 2000.

420E/420E IT Backhoe Loaders, Caterpillar.

Heavy Equipment Operations: Level Two, 3rd ed., National Center for Construction Education and Research, Gainesville, FL and Pearson Education, Inc., Upper Saddle River, NJ, 2006.

International 510 Series B/515 Series B Payloader, Operator's Manual, International-Hough, East Sunnyside Avenue, Libertyville, IL, 1985.

Navy 420 DV Backhoe Loader: Training Material, Caterpillar, 2004.

Nichols, Herbert L., Jr., *Moving the Earth*, 3rd ed., North Castle Books, Inc., Greenwich, CT, 1985.

Pruess, E. D., *The Rubber Tired Tractor Shovel*, Construction Machinery Division, Clark Equipment Company, Benton Harbor, MI, 1989.

CSFE Nonresident Training Course – User Update

CSFE makes every effort to keep their manuals up-to-date and free of technical errors. We appreciate your help in this process. If you have an idea for improving this manual, or if you find an error, a typographical mistake, or an inaccuracy in CSFE manuals, please write or email us, using this form or a photocopy. Be sure to include the exact chapter number, topic, detailed description, and correction, if applicable. Your input will be brought to the attention of the Technical Review Committee. Thank you for your assistance.

Write: CSFE N7A
3502 Goodspeed St.
Port Hueneme, CA 93130

FAX: 805/982-5508

E-mail: CSFE_NRTC@navy.mil

Rate____ Course Name_____

Revision Date_____ Chapter Number____ Page Number(s)_____

Description

_____

_____

_____

(Optional) Correction

_____

_____

_____

(Optional) Your Name and Address

_____

_____

_____

Chapter 15

Excavators

Topics

To hear audio, click on the box. 

Overview

Like the backhoe, the excavator can dig trenches and ditches as well as load trucks. In addition, it can perform light duty hoisting; however, its unique upper structure rests on a turntable capable of rotating 360 degrees, allowing the excavator to perform in tight area.

This chapter provides you the information needed to successfully execute excavation operations. This chapter describes the types of excavators used by the Naval Construction Force (NCF). It includes a description of major components, controls, and attachments. In addition, this chapter explains how to perform digging and lifting operations. Last, it lists safety practices.

Objectives

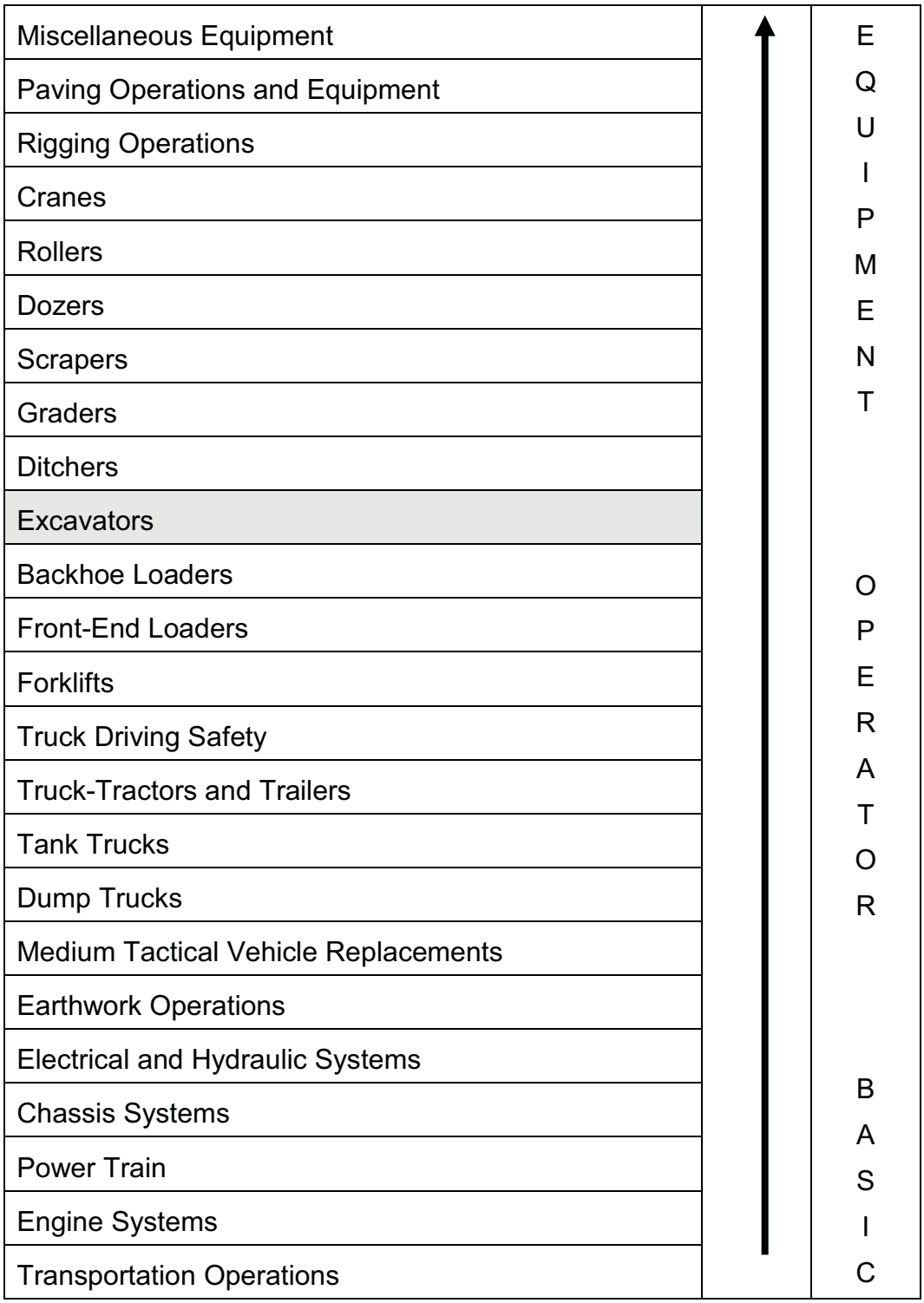
When you have completed this chapter, you will be able to do the following:

1. Understand the use of excavators.
2. Identify types of excavators used by NCF.
3. Identify the major components of excavators.
4. Identify the controls on the excavator.
5. Identify excavator attachments and their use.
6. Understand how to perform excavator operations.
7. Understand excavator safety.

Prerequisites

None

This course map shows all of the chapters in Equipment Operator Basic. The suggested training order begins at the bottom and proceeds up. Skill levels increase as you advance on the course map.



Features of this Manual

This manual has several features which make it easy to use online.

- Figure and table numbers in the text are italicized. The figure or table is either next to or below the text that refers to it.
- The first time a glossary term appears in the text, it is bold and italicized. When your cursor crosses over that word or phrase, a popup box displays with the appropriate definition.
- Audio and video clips are included in the text, with italicized instructions telling you where to click to activate it.
- Review questions that apply to a section are listed under the Test Your Knowledge banner at the end of the section. Select the answer you choose. If the answer is correct, you will be taken to the next section heading. If the answer is incorrect, you will be taken to the area in the chapter where the information is for review. When you have completed your review, select anywhere in that area to return to the review question. Try to answer the question again.
- Review questions are included at the end of this chapter. Select the answer you choose. If the answer is correct, you will be taken to the next question. If the answer is incorrect, you will be taken to the area in the chapter where the information is for review. When you have completed your review, select anywhere in that area to return to the review question. Try to answer the question again.

1.0.0 EXCAVATORS

Excavators are capable of digging deeper and more efficiently than most other earthmoving equipment, excavators, like the one shown in *Figure 15-1*, are primarily used to dig above and below grade; they can also be used to trench, lay pipe, and load material. With the proper attachment, they can also compact soil or break up concrete and rock.

Figure 15-1 – Excavator.

Excavators are large backhoes used for heavier construction tasks. They are equipped with a hoe, similar to an excavating arm, made up of a boom, dipper arm, and bucket. The hoe, operator's cab, and engine compartment make up the upper structure of the excavator. The upper structure is often referred to as the revolving unit because it rests and rotates on a turntable supported by an ***undercarriage*** with wheels or tracks. The turntable is capable of rotating 360 degrees, allowing the operator to dig facing one direction and quickly rotate in any direction to load a dump truck, as shown in *Figure 15-2*.

Figure 15-2 – Loading a dump truck.

This unique design allows excavators to load in tighter areas in a timelier manner. A truck can be positioned on each side of the excavator, and after one truck is full, the excavator can rotate quickly to the other and begin loading. This design also allows the excavator to lift itself out of mud or onto a trailer for long-distance travel. This movement is done by applying downward pressure on the bucket.

1.1.0 Types of Excavators Used By Naval Construction Force

Excavators come in a wide variety of sizes and capacities ranging from small. They are also available in various configurations including wheel-, track-, and truck-mounted equipped with a standard straight hydraulic or a telescoping boom. *Figure 15-3* shows a truck-mounted excavator with a standard straight hydraulic boom.

Figure 15-3 – Truck-mounted excavator with a standard hydraulic boom.

The NCF commonly uses wheel- and track-mounted excavators with standard booms to perform heavy construction tasks. Before selecting an excavator for a particular job, operators must consider the following characteristics associated with these types of excavators.

1.1.1 Wheel-Mounted Excavator

The undercarriage on the wheel-mounted excavator can have two or more wheel axles. The tires on these axles provide great mobility and allow the excavator to be driven a short distance to and from job sites on paved roads. The wheel-mounted excavator can load and unload hauling trucks, as well as move loads around the job site. Like the backhoe loader, it is equipped with stabilizers that are hydraulically lowered for additional stability when digging; however, unlike the backhoe loader, they are attached to the front of the undercarriage.

The wheel-mounted excavator can also have a push-back blade attached to the rear of the undercarriage. It is used to level the work area prior to operation. When the blade is lowered firmly on the ground, it provides greater stability.

When traveling, always check the travel route for weight, height, and width limits. Make sure that the boom and steering selector are placed in the travel position, and that the swing brake is engaged. Do not travel with the boom over the side of the excavator, and if traveling off the road, do not travel faster than 5 miles per hour.

NOTE

After 2 hours of highway travel or every 50 miles, whichever occurs first, stop the machine to let the tires cool for 1/2 hour. Heat damages the tires and can cause tire failure.

1.1.2 Track-Mounted Excavator

Compared to wheels, the tracks on the track-mounted excavator, shown in *Figure 15-4*, provide greater flotation and traction in unfavorable conditions. In addition, the tracks provide sufficient stability that stabilizers and a push-back blade are not needed. Not having these components to raise and lower saves time when repositioning the track-mounted excavator at each excavation. Unlike the wheel-mounted excavator, the track-mounted cannot be driven on paved roads, but instead, must be transported by trailer.

Figure 15-4 – Track-mounted excavator.

Test your Knowledge (Select the Correct Response)

1. **(True or False)** The excavator is only used to dig below grade.

   A. True
   B. False

2. Which of the following components does NOT make up the excavator's revolving unit?

   A. Hoe
   B. Operator's cab
   C. Engine compartment
   D. Tracks

2.0.0 MAJOR COMPONENTS

Major components and controls on excavators vary among makes and models. You are responsible for reading the operator's manual for specific information. *Figure 15-5* shows the major components of a John Deere 200CLC track-mounted excavator.

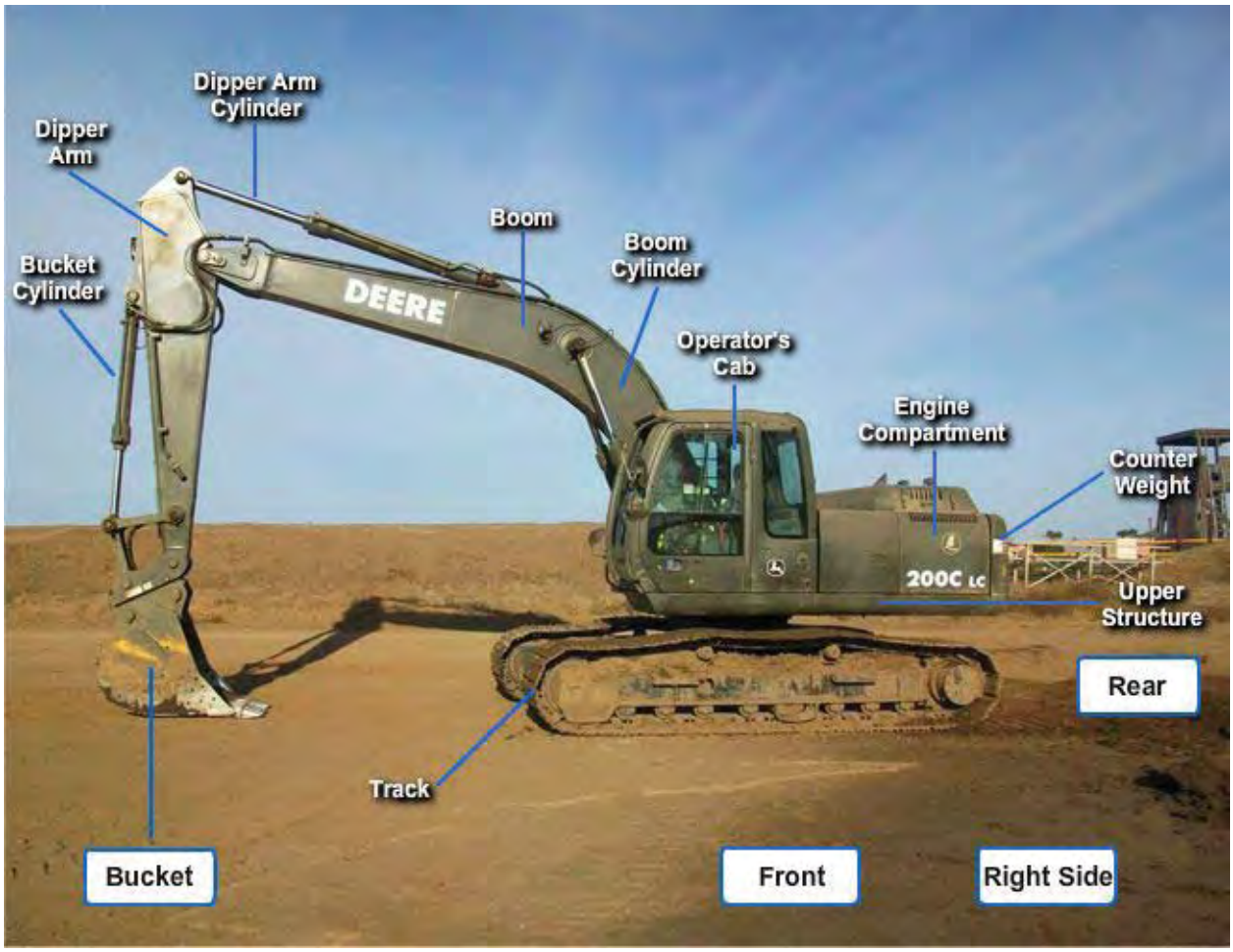


Figure 15-5 – Major components.

2.1.0 Operator's Cab

The operator's cab is the front half of the revolving unit. On the John Deere 200CLC, it is located on the right side of the boom; however, the operator's cab can be mounted on either the right or left side. The operator's cab is the location of controls, gauges, and monitor panel, as shown earlier in *Figure 15-5*.

Some excavators may have fixed or removable front and side windows, and a roof window that is helpful in watching out for and avoiding wires and tree branches. These windows should be cleaned during the pre-start check and anytime an accumulation of dust and dirt on the window obstructs your vision.

It is worth mentioning that the center of rotation is usually the front, center of the revolving unit, placing a major part of the revolving unit weight at the rear. This serves to counterbalance the weight and pull of the backhoe when performing excavation operations.

The swing axis is centered in the undercarriage, so the rear edge of the revolving unit overhangs. You must account for this overhang when you rotate the revolving unit from side to side to avoid hitting personnel, equipment, and buildings.

2.2.0 Hoe

The hoe is made of three strong structural members: the boom, dipper arm, and bucket. These structural members are hinged to each other, and the boom is hinged to the revolving unit. Movement at each hinge is controlled by two-way hydraulic cylinders. *Figure 15-6* shows the excavator's range of motion.

Figure 15-6 – Range of motion.

2.2.1 Boom

The boom is normally concave towards the ground, a design that allows space to pull the bucket closer to the excavator, permits deeper digging without interference from the undercarriage, and enables the operator to see past it more easily when it is raised.

Some excavators have two holes for connecting the cylinder rod eye to the boom, as shown in *Figure 15-7*. The top hole is for maximum digging depth, and the bottom hole is for maximum dump height. Be sure to read the operator's manual for instructions on the boom height-depth adjustment.

The outer end of the boom is usually prolonged into a two-piece bracket, in which the dipper arm is held by a heavy hinge pin or pins.

1. To increase the dig depth 2. To increase the dump height

Figure 15-7 – Boom depth-height adjustment.

2.2.2 Dipper Arm

The dipper arm is usually one piece, but some models may hydraulically extend and retract by a telescoping boom. The dipper arm hydraulic crowd cylinder is connected either on the top or on the bottom of the dipper, and the bucket and bucket dump arms are connected at the end.

If the dipper arm hydraulic crowd cylinder is mounted on the top, extending the cylinder forces the bucket in towards the machine, known as "crowding." Retracting the cylinder forces the bucket outward, known as "extending." When the cylinder is mounted underneath the boom, retracting the cylinder crowds the dipper arm, and extending the cylinder extends the dipper arm.

WARNING

When working off the rear of an excavator that has the dipper arm hydraulic cylinder mounted on the bottom, in deep digging, use caution to keep the dipper arm hydraulic cylinder far enough from the excavator to allow proper clearance when swinging.

The bucket cylinder is hinged to the top or front side of the dipper arm. The hydraulic cylinder rod is connected to the bucket dump arms that are hinged to the dipper arm.

The bucket mounting is normally connected to the lower end of the dipper arm by a hinge pin and to a triangular set of paired dump arms. The other two angles of the arms are hinged to the bucket cylinder rod and to the dipper arm.

Dump arms supply the required around-a-curve reach and prevent the cylinder from being pulled in against the dipper arm when extending. The arm is necessary because the bucket has such an extended arc of rotary movement around the dipper arm hinge that the piston arm could not follow it. When the hydraulic cylinder is extended, the bucket teeth move inward in a curling or digging motion. When the hydraulic cylinder is retracted, the bucket dumps, opens, or extends.

2.2.3 Bucket

The bucket can be attached to the bucket mounting in a variety of ways. One way is the slow process of removing cotter pins and manually driving out hinge pins to change the attachment. Another way is a “quick-latch” mounting where the pins are retained in the attachment, and the quick-latch mounting latches on the pins are secured to the attachment by a large bolt. A third way is a quick disconnect that uses hydraulically controlled locking pins that the operator controls from the cab.

Figure 15-8 shows how the width of a bucket determines how narrow of a trench it can dig. For this reason, buckets are available in various widths. A bucket is usually slightly wider at the opening to reduce friction at the sides when digging and to allow easier dumping. Narrow buckets tend to be deep in proportion to width and may fill poorly in chunky or rocky digging, while wide buckets may have poor penetration. The digging edge is almost always equipped with teeth that are removable for reversing, sharpening, or replacing, as shown in *Figure 15-9*.

Figure 15-8 – Wide trench.

Figure 15-9 – Detachable tooth.

Test your Knowledge (Select the Correct Response)

3. What structure members make up the hoe on the excavator?

   A. Dipper arm, dipper stick, and bucket
   B. Boom, dipper arm, and bucket
   C. Boom, digging arm, and bucket
   D. Dipper arm, bucket, and revolving unit

4. The bottom adjustment hole that connects the cylinder rod eye to the boom provides what maximum operation?

   A. Dump height
   B. Digging depth
   C. Reach
   D. 360 degree rotation

3.0.0 CONTROLS

The typical excavator has a variety of travel pedals, levers and joysticks used to steer, move the dipper arm in and out, raise and lower the boom, and load and dump the bucket. *Figure 15-10* shows the controls on a John Deere 200CLC and their actions.

Figure 15-10 – Travel pedals, levers, and control joysticks.

Most excavators have a safety device to prevent the accidental movement of hydraulic controls. In the case of the John Deere 200CLC, the travel pedals, levers, and joysticks are operational only when the pilot control shut-off lever, shown earlier in *Figure 15-8,* is pushed forward to the unlocked position.

As a safety precaution, the pilot control shut-off lever should always be in the locked position when the engine has been turned off or when the operator leaves the cab.

3.1.0 Travel Pedals and Levers

Because the levers are attached to the backsides of the travel pedals, you can choose to use either the pedals or the levers to control the speed, traveling direction, and rotation of the excavator. When you are seated, the pedals and levers are situated in front of you. Each pedal and lever has three positions: forward, center, and back.

- To travel forward, at the same time press down on the toe end of both pedals or push both levers forward. Speed is determined by how far down you press down on the pedals or how far forward you push the levers.

- To travel in reverse, at the same time press down on the heel end of both pedals or pull both levers back.
- To engage the travel brakes to stop and hold the excavator, both pedals and levers must be in the center position.
- To make a right turn, press down on the toe end of the left pedal or push the left lever forward.
- To make a left turn, press down on the toe end of the right pedal or push the right lever forward.
- To make a sharp right turn (counter-rotate), at the same time press down on the toe end of the left pedal and the heel end of the right pedal. This can also be done by pushing the left lever forward and pulling the right lever back at the same time.
- To make a sharp left turn (counter-rotate),, at the same time press down on the toe end of the right pedal and the heel end of the left pedal. This can also be done by pushing the right lever forward and pulling the left lever back at the same time.

The patterns for operating the traveling pedals and levers are shown in *Figure 15-11*.

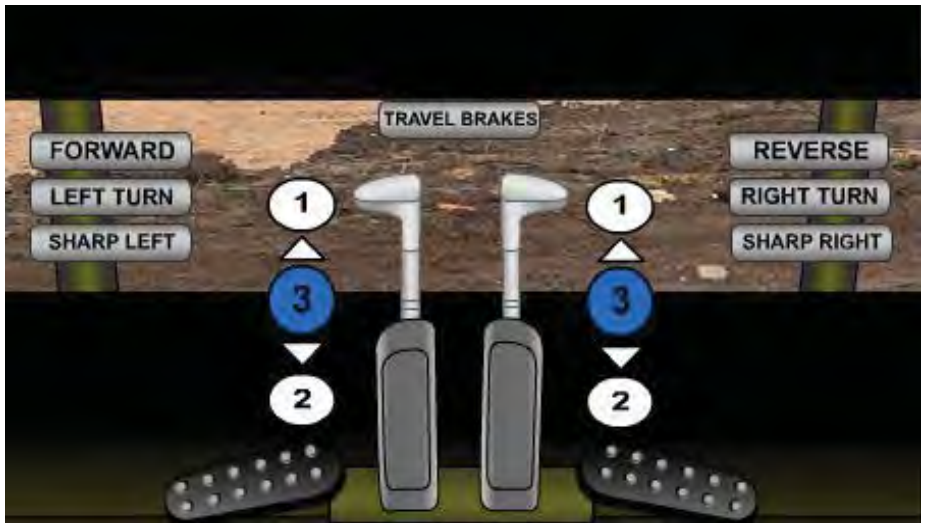


Figure 15-11 – Operation of traveling pedals and levers.

CAUTION

Prevent possible injury from the excavator tipping by operating the control pedal or lever slowly when traveling down a slope.

3.2.0 Control Joysticks

A complete ***work cycle*** involves the operation of two joysticks at the same time. These joysticks are situated on the left and right side of the operator. Each joystick has five positions: forward, back, left, right, and center.

Although each joystick controls specific movements, the center positions stop the movement of the excavator. In addition, when the control joysticks are released, they will return to the center position, whereupon the movement of the excavator will stop.

3.2.1 Left-Side Joystick

The left-side joystick controls the in and out movement of the dipper arm and left and right swing of the upper structure.

- To move the dipper arm out, push the left-side joystick forward.
- To move the dipper arm in, pull the joystick back.
- To swing the upper structure left or right, move the joystick towards the desire direction.

3.2.2 Right-Side Joystick

The right-side joystick controls the up and down movement of the boom. It also controls the loading and dumping of the bucket.

- To lower the boom, push the right-side joystick forward.
- To raise the boom, pull the joystick back.
- To load the bucket, move the joystick left.
- To dump the bucket, move the joystick right.

Figure 15-12 allows you to operate both the left- and right-side joysticks.

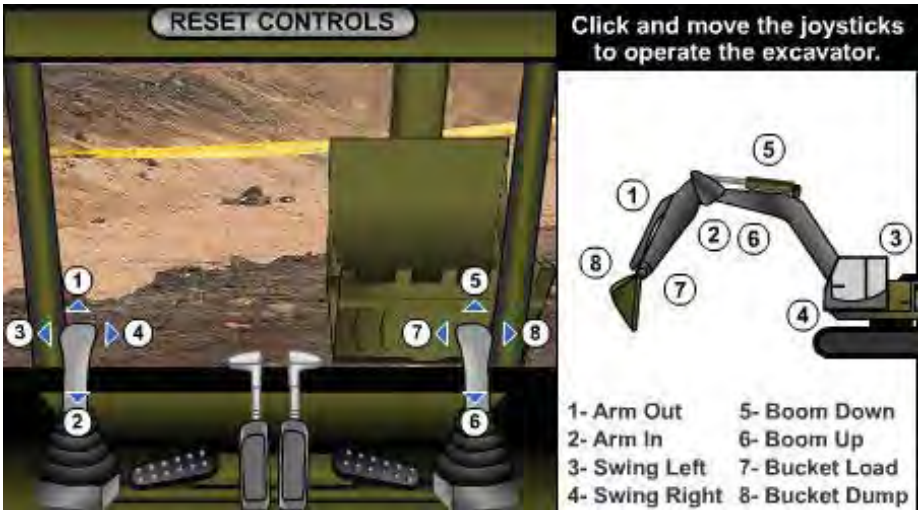


Figure 15-12 – Operating control joysticks.

NOTE

The excavator comes equipped from the factory with control lever patterns and has the corresponding black-on-white labels installed on the left and right control consoles.

CAUTION

Prevent injury from unexpected control lever function. Be aware of the control lever pattern used on the machine before operating.

Test your Knowledge (Select the Correct Response)

5. On the John Deere 200CLC, one option for steering is to use the _____.

   A. steering wheel
   B. pedals
   C. left-side joystick
   D. right-side joystick

6. On the John Deere 200CLC, what prevents the accidental movement of hydraulic pedals, levers, and joysticks?

   A. Pilot control shut-off lever
   B. Parking brake
   C. Emergency brake
   D. Engine shut-off

4.0.0 ATTACHMENTS

Beyond the standard excavating bucket discussed earlier, many other types of attachments are used with the excavator. These attachments include the hydraulic breaker and compactor. These attachments serve different purposes. Before using any attachment, read the manufacturer's instructions for the specific excavator and attachment to ensure compatibility.

4.1.0 Hydraulic Breaker

The hydraulic breaker, like the one shown in *Figure 15-13*, is also called a hydraulic hammer. As shown in *Figure 15-14*, it is used like a jackhammer during demolition for breaking rock and thick slabs of concrete.

Figure 15-13 – Hydraulic breaker.

Figure 15-14 – Breaking concrete.

When using the hydraulic breaker, ensure the excavator is in a stable position and not on a crumbling or slippery surface. Doing so guarantees a constant, even pressure on the hammer. In addition, always keep the breaker perpendicular to the surface to be broken and free of obstructions, chaffing, or interference, as shown in *Figure 15-15*. This will extend the life of the breaker.

Figure 15-15 – Proper position of breaker.

While operating the breaker, if you hear metallic strokes, rather than sharp strokes, the downward pressure from the boom is too weak or the hammer is not striking the surface correctly. This can be solved by exerting more pressure or ensuring the hammer is in the correct position. If there is strong vibration in the excavator and breaker, the downward pressure is excessive. This can be solved by slightly raising the boom to reduce pressure. If vibration continues, it may be due to an internal hydraulic leak. In this case, report it to the maintenance shop.

As soon as cracks appear in the material, stop the breaker immediately. Do not raise the breaker from the material until it has stopped completely.

If cracks do not appear within 30 seconds after starting operation, move to a new position along the grain of the material, perhaps working on a smaller section or edge of the material.

4.2.0 Compactor

After trenches or excavated areas are backfilled, the compactor attachment is used to compact the soil to specified finishing standards. The NCF commonly uses the vibratory plate compactor, like the one shown in *Figure 15-16*. Such a compactor is available in various sizes.

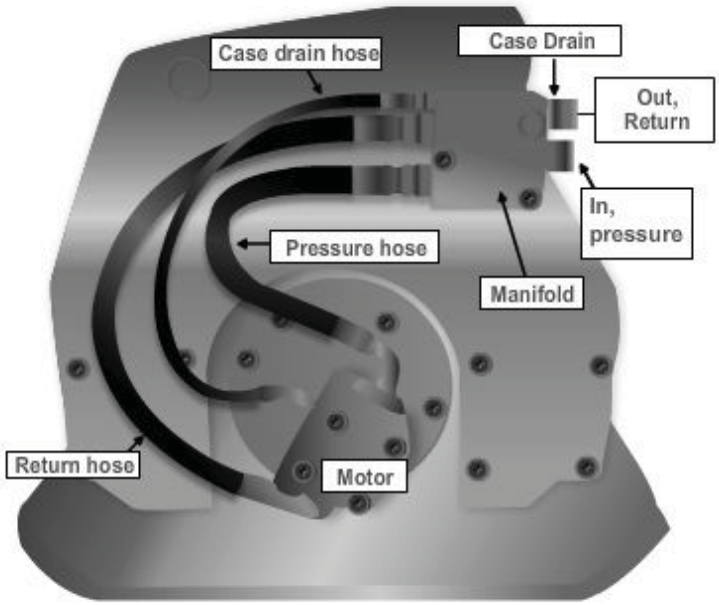


Figure 15-16 – Vibratory plate compactor.

Test your Knowledge (Select the Correct Response)

7. Which of the following attachments is used with the excavator for breaking rock during demolition?

   A. Compactor
   B. Hydraulic breaker
   C. Jack hammer
   D. Grapple

5.0.0 OPERATIONS

Excavator operations are similar, if not identical, to backhoe operations; therefore, for more information about trenching and loading, excavating foundations, and setting pipe, refer to Chapter 14 Backhoe Loaders. Below are additional excavation operations.

5.1.0 Digging Procedures

If you are unfamiliar with the controls or have not operated an excavator in a while, use a slow engine speed while you familiarize yourself with each control. At first, operate the controls separately; then operate two or more controls at the same time. Basic digging procedures are as follows:

Step 1. Wear the proper personal protective equipment for the job, including steel-toe safety shoes, a hard hat, and gloves.

Step 2. Check the ground conditions before you start to dig.

Step 3. Obtain a digging permit and know the location of any underground cables and pipelines.

Step 4. Check for overhead obstructions such as electrical lines, tree limbs, and awnings.

Step 5. Remove large rocks, stumps, or other obstructions before you begin to dig.

Step 6. When you are digging, use a digging stroke that will fill the bucket. Full buckets are more efficient and faster than half-full buckets.

Step 7. Try different digging angles with the bucket to find the best cutting effort for the material you are removing. The best digging angle cuts the material as you fill the bucket.

Step 8. When filling the bucket, keep the bottom of the bucket parallel with the cut. Let the bucket teeth and the cutting edge cut through the ground like a knife blade. Curl the bucket to retain the cut material. These produces are all shown in *Figure 15-17.*

Step 9. The type of material excavated will determine how much material can be excavated with each cycle.

Figure 15-17 – Filling the bucket.

5.2.0 Trenching

Using an excavator to dig and backfill trenches is similar to using a backhoe, except that the excavator's undercarriage is positioned parallel to the trench, as shown in *Figure 15-18*.

Figure 15-18 – Parallel position at trench.

5.3.0 Job Layout

Many excavation jobs are small and routine. Other jobs may be quite extensive. On small jobs, you will normally be shown where and to what depth to dig. On larger jobs, you may be shown the plan of the proposed ditches. Grade stakes on the projects are marked to indicate to what depth the ditches must be excavated. Chapter 5, Earthwork Operations covers grade stakes in detail.

NOTE

Before starting any excavation, you must ensure a valid digging permit is present that covers the area you are tasked to excavate.

When arriving at the project site, you may notice two rows of grade stakes: one row on the center line of the proposed ditch and the other row offset a given distance from the center line. Do not disturb the offset stakes. They are the stakes you will follow while excavating the ditch; they have information relative to the depth of the excavation written on the sides.

As a guideline, you can use a string drawn taut from the first centerline stake to the following centerline stakes for a distance of several hundred feet ahead of the machine. Then you can spray paint over the string with a bright-colored paint that will mark the ground to be excavated. With the bucket centered over the first centerline stake, you will be able to excavate the painted line. If you get off center, you can bring the backhoe back into alignment gradually by steering the machine in the desired direction.

Check your grade (ditch depth) frequently. You can do this by using a straight board, a carpenter's level, and a measuring stick or tape measure. Align the corner bottom of the horizontal board on the crowfoot cut, marking of the offset stake. Place the level on the horizontal board and adjust the board opposite the stake until the level indicates the board is level. Measure from the bottom edge of the board to the bottom of the ditch, as shown in *Figure 15-19*. This measurement should correspond to the amount of cut indicated on the stake. All of the stakes will be cut stakes. You should always try to excavate to the depth specified on the stakes.

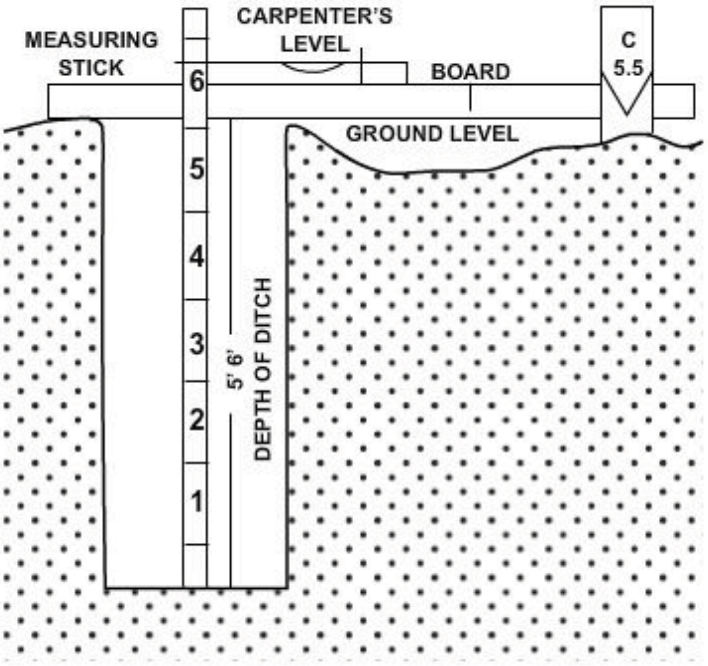


Figure 15-19– Measuring the depth of a ditch.

NOTE

It is better to excavate an inch or two below grade than not to excavate deep enough.

5.4.0 Lifting

The excavator may be used to lift heavy sections of pipe into a trench, or to hoist and unload materials from trucks. The weight an excavator can lift depends on the excavator's weight, center of gravity, locations of lift hooks, and hydraulic capabilities. Always refer to the operator's manual for lift capacity before attempting to lift. In addition, position the excavator as close to the load as possible. The other critical elements to consider are swing and position. The lifting capability is 65 to 70 percent greater over the front of the excavator than over the side.

Test your Knowledge (Select the Correct Response)

8. **(True or False)** The bucket should be parallel with the cut when filling the bucket.

   A. True
   B. False

9. **(True or False)** It is better NOT to excavate enough than to excavate an inch or two below grade.

   A. True
   B. False

6.0.0 SAFETY

Safety precautions that apply when you operate an excavator are as follows:

- Clear the immediate area of personnel or obstructions before starting the engine.
- Keep the bucket as close to ground level as possible when transporting loads on grades or slopes.
- Never operate any control from any position except in the operator's seat.
- Be extra careful when working on banks or hillsides. On steep or slippery slopes, position the undercarriage so that the engine compartment will be on the uphill end of the machine.
- Always keep the machine in gear when going down steep grades. Never coast or freewheel.
- Drive at speeds slow enough to ensure safety and complete control, especially over rough terrain.
- Reduce speed when making turns or applying brakes.
- Never dismount the excavator when it is in motion.
- Never permit anyone to ride on the equipment.
- Do NOT oil, lubricate, or make adjustments when the engine is running or the bucket is raised and unblocked.
- Never refuel when the engine is running.
- Do NOT smoke when refueling.
- Never operate in a closed area; provide proper ventilation.
- Do NOT wear loose-fitting clothing which may catch in moving parts.

- Always wear seat belts, steel-toe safety shoes, hard hats, gloves, and other required personal protective equipment.
- Before moving the machine, be sure all persons are clear of both travel and swing paths.
- Use a signal person when backing if view is obstructed or when in close quarters. Keep signal person in view at all times. Use prearranged hand signals to communicate.

Test your Knowledge (Select the Correct Response)

10. On steep or slippery slopes, how should the engine be positioned?

    A. On the uphill end of the excavator
    B. On the downhill end of the excavator
    C. At an angle to the slope
    D. Diagonal to the slope

Summary

Excavators are extraordinary construction equipment, capable of rotating in any direction. They are available in various configurations, including wheel-, track- and truck-mounted, and are equipped with standard hydraulic or telescoping booms.
This chapter introduced you to one specific model of track-mounted excavator, the John Deere 200CLC. You were introduced to its hoe, consisting of a boom, dipper arm, and bucket. You were briefly introduced to the operations of its travel pedals and levers and control joysticks. You were also introduced to the hydraulic breaker and compactor, attachments used with excavators to increase work productivity. Last, this chapter introduced you to digging and lifting operations and safety practices to adhere to when performing such operations.

Review Questions (Select the Correct Response)

1. **(True or False)** The NCF uses excavators with hydraulic telescoping booms.

   A. True
   B. False

2. Which of the following components is NOT part of the excavator's hoe?

   A. Boom
   B. Bridle assembly
   C. Dipper arm
   D. Bucket

3. Which of the following excavator has stabilizers and a push-back blade?

   A. Wheel-mounted excavator
   B. Track-mounted excavator
   C. Truck-mounted excavator
   D. Telescoping excavator

4. **(True or False)** Stabilizers are attached to the rear of the undercarriage.

   A. True
   B. False

5. **(True or False)** Excavators can lift themselves out of mud or onto trailers.

   A. True
   B. False

6. What is the purpose of the push-back blade?

   A. To move loads
   B. To increase load retention
   C. To level the work area
   D. To compact soil

7. When traveling with an excavator, you should check the travel route for which of the following limits?

   A. Weight
   B. Height
   C. Width
   D. All of the above

8. When driving a wme for 2 hours or 50miles, whichever occurs first, you should stop and let the tires cool for what minimum amount of time?

   A. ½ hour
   B. 1 hour
   C. 2 hours
   D. 3 hours

9. An excavator boom that is concave toward the ground allows which of the following advantages?

   A. Space to pull the bucket close to the excavator
   B. Deep digging
   C. Ability for operator to see past it when raised
   D. All of the above

10. **(True or False)** A bucket is usually slightly wider at the rear to reduce friction.

   A. True
   B. False

11. On the John Deere 200CLC, using the travel pedals, how would an operator make a right turn?

   A. Press down on the toe end of the left pedal.
   B. Press down on the heel end of the left pedal.
   C. Press down on the toe end of the right pedal.
   D. Press down on the heel end of the right pedal.

12. On the John Deere 200CLC, using the travel levels, how would an operator make a sharp left turn?

   A. At the same time push the right lever forward and pull the left lever back.
   B. At the same time push the left lever forward and pull the right lever back.
   C. At the same time push the left and right lever forward.
   D. At the same time pull the left and right lever back.

13. **(True or False)** On the John Deere 200CLC, the left-side joystick controls the in and out movement of the dipper arm.

   A. True
   B. False

14. On the John Deere 200CLC, how would an operator dump the bucket?

   A. Move the left-side joystick right.
   B. Move the left-side joystick left.
   C. Move the right-side joystick right.
   D. Move the right-side joystick left.

15. While operating with a hydraulic breaker, what is the cause of metallic strokes?

    A. Excessive downward pressure from the boom
    B. Inadequate downward pressure from the boom
    C. An internal hydraulic leak
    D. Cracks in the material

16. How can an operator extend the life of a hydraulic breaker?

    A. Keep the breaker at an angle from the surface to be broken.
    B. Keep the breaker perpendicular to the surface to be broken.
    C. Raise the breaker from the material while it is still operation.
    D. Increase downward pressure from the boom.

17. What item determines how much material can be excavated during each digging cycle?

    A. Engine rpm
    B. Operator's expertise
    C. Length of the dipper arm
    D. Type of material

18. Before performing any type of excavation, an operator should check on or obtain what type of permit?

    A. Landscaping
    B. Operators
    C. Digging
    D. Environmental

19. What grade stakes should an operator NOT disturb when excavating a ditch because they are used as a reference?

    A. Offset
    B. Centerline
    C. Shoulder
    D. Slope

20. **(True or False)** The lifting capability is 65 to 70 percent greater over the side than over the front of the excavator.

    A. True
    B. False

21. **(True or False)** It is a safe practice to ensure all persons are clear of both travel and swing paths before moving an excavator.

    A. True
    B. False

Terms Introduced in this Chapter

Undercarriage	An assembly that supports the upper structure of an excavator or crane. It consists of a frame, a swing bearing, or hook and load rollers, travel mechanism, and steering mechanism. The undercarriage may be either a crawler or wheeled type.
Work cycle	A complete set of operations. In an excavator, it usually includes loading, moving, dumping, and returning to the loading point.

Additional Resources and References

This chapter is intended to present thorough resources for task training. The following reference works are suggested for further study. This is optional material for continued education rather than for task training.

Case, 1085B Cruz-Air Excavator, Operator's Manual, J. I. Case Company, 2525 West Hampton Avenue, Milwaukee, WI, 1985.

Earthmoving Operations, FM 5-434, Headquarters Department of the Army, Washington, DC, 2000.

Heavy Equipment Operations: Level Two, 2nd ed., National Center for Construction Education and Research, Gainesville, FL and Pearson Education, Inc., Upper Saddle River, NJ, 2006.

International 510 Series B/515 Series B Payloader, Operator's Manual, International-Hough, East Sunnyside Avenue, Libertyville, IL, 1985.

Nichols, Herbert L., Jr., *Moving the Earth*, 3rd ed., North Castle Books, Inc., Greenwich, CT, 1985.

Operator's Manual: 200CLC Excavator, John Deere, OMT187348 Issue F6.

Pruess, E. D., *The Rubber Tired Tractor Shovel*, Construction Machinery Division, Clark Equipment Company, Benton Harbor, MI, 1989

CSFE Nonresident Training Course – User Update

CSFE makes every effort to keep their manuals up-to-date and free of technical errors. We appreciate your help in this process. If you have an idea for improving this manual, or if you find an error, a typographical mistake, or an inaccuracy in CSFE manuals, please write or email us, using this form or a photocopy. Be sure to include the exact chapter number, topic, detailed description, and correction, if applicable. Your input will be brought to the attention of the Technical Review Committee. Thank you for your assistance.

Write: CSFE N7A
3502 Goodspeed St.
Port Hueneme, CA 93130

FAX: 805/982-5508

E-mail: CSFE_NRTC@navy.mil

Rate____ Course Name_____

Revision Date_____ Chapter Number____ Page Number(s)_____

Description

_____

_____

_____

(Optional) Correction

_____

_____

_____

(Optional) Your Name and Address

_____

_____

_____

Chapter 16

Ditchers

Topics

To hear audio, click on the box. 

Overview

Ditchers support construction operations any time there is a need to dig a trench for underground utilities and conduit to handle water, fuel, electric cable, or sewage.

This chapter provides you the information needed to successfully conduct such operations. It describes the types of ditcher used by Naval Construction Force (NCF), including major components, controls, capabilities and limitations. In addition, this chapter explains how to cut curves and trench in muddy conditions. Lastly, it lists safety practices.

Objectives

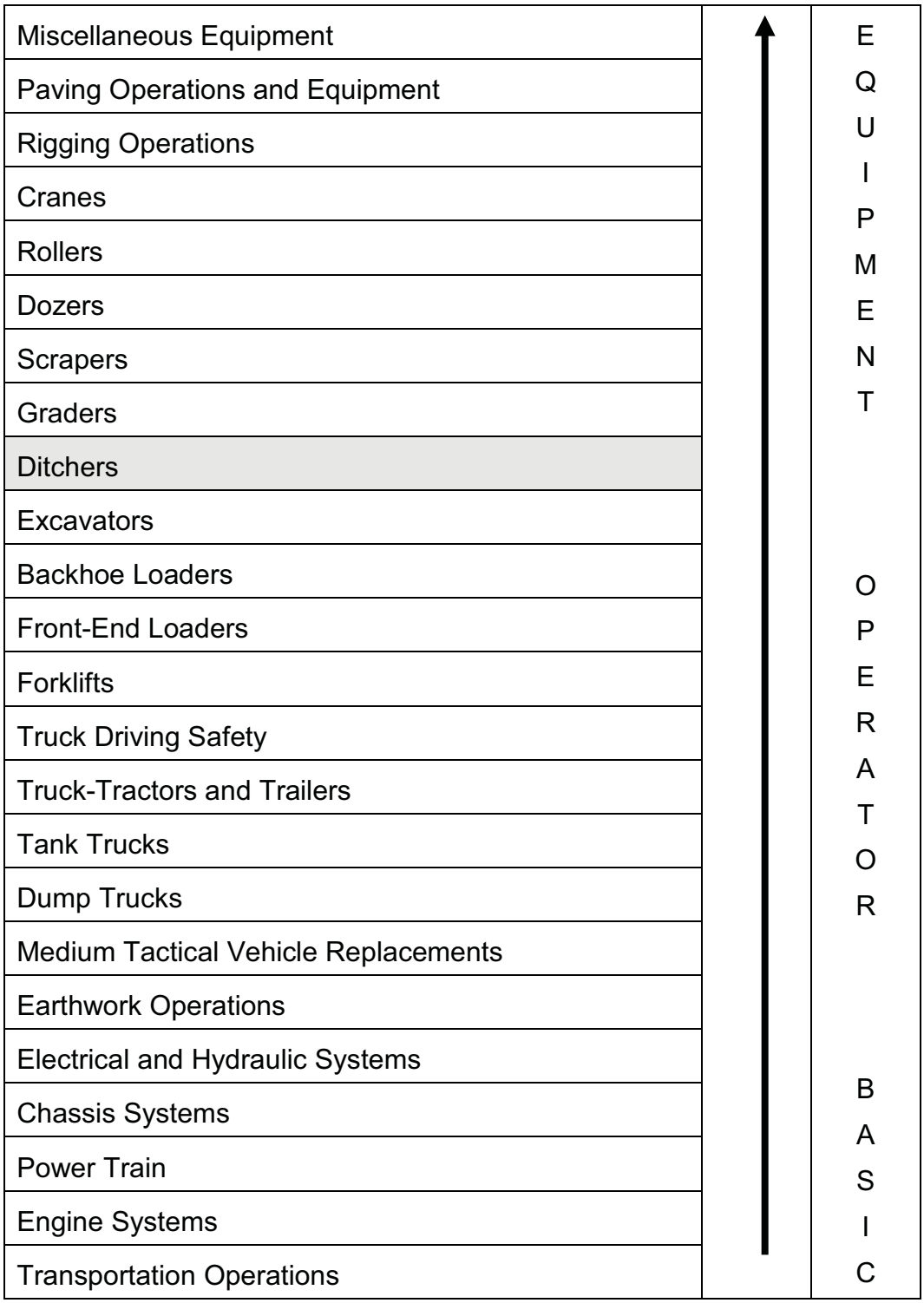
When you have completed this chapter, you will be able to do the following:

1. Understand the use of ditchers.
2. Identify types of ditchers used by NCF.
3. Identify the major components of ditchers.
4. Identify the controls on the ditcher.
5. Understand the capabilities and limitations of ditchers.
6. Understand how to perform ditcher operations.
7. Understand ditcher safety.

Prerequisites

None

This course map shows all of the chapters in Equipment Operator Basic. The suggested training order begins at the bottom and proceeds up. Skill levels increase as you advance on the course map.



Features of this Manual

This manual has several features which make it easy to use online.

- Figure and table numbers in the text are italicized. The figure or table is either next to or below the text that refers to it.
- The first time a glossary term appears in the text, it is bold and italicized. When your cursor crosses over that word or phrase, a popup box displays with the appropriate definition.
- Audio and video clips are included in the text, with italicized instructions telling you where to click to activate it.
- Review questions that apply to a section are listed under the Test Your Knowledge banner at the end of the section. Select the answer you choose. If the answer is correct, you will be taken to the next section heading. If the answer is incorrect, you will be taken to the area in the chapter where the information is for review. When you have completed your review, select anywhere in that area to return to the review question. Try to answer the question again.
- Review questions are included at the end of this chapter. Select the answer you choose. If the answer is correct, you will be taken to the next question. If the answer is incorrect, you will be taken to the area in the chapter where the information is for review. When you have completed your review, select anywhere in that area to return to the review question. Try to answer the question again.

1.0.0 DITCHERS

A ditcher, despite its name, is seldom used for digging a ditch, which is a slot cut in the earth's surface and left open. The ditcher is a mechanical excavator used to dig trenches, which are temporary cuts in the earth for underground utilities, such as pipelines and conduit to handle water, fuel, electric cable, and sewage. Once these materials are placed, the trench is covered. *Figure 16-1* shows an aerial view of a trench dug by a ditcher. Ditchers may also be used to dig footers for building foundations.

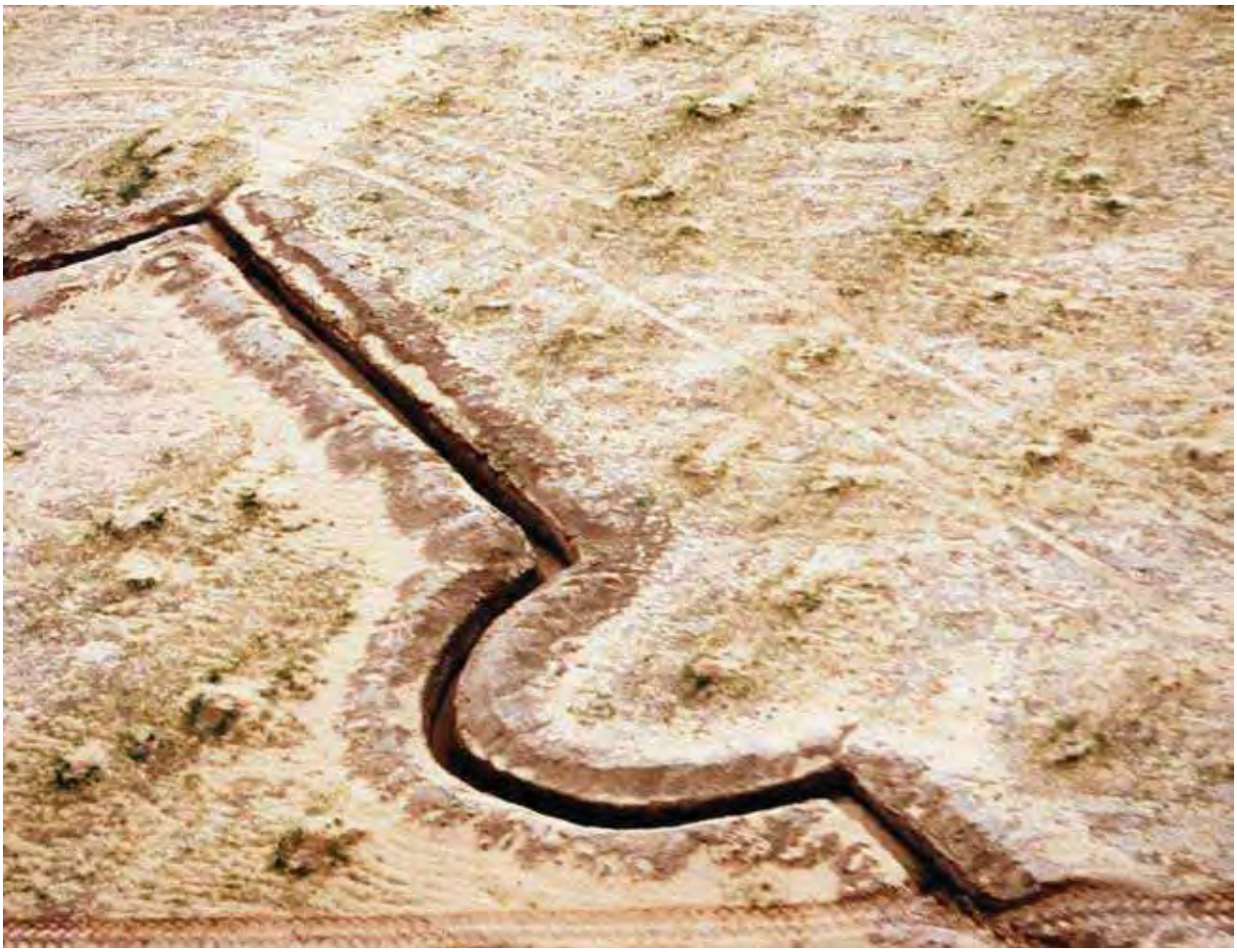


Figure 16-1 – Trench dug by ditcher.

1.1.0 Types of Ditchers Used By Naval Construction Force

The NCF uses three types of ditchers: the wheel, ladder, and chain ditcher.

1.1.1 Wheel Ditcher

Mounted on crawler tracks, the wheel ditcher has digging buckets attached to a front-end large wheel (*Figure 16-2*). The wheel is attached to a frame-type horizontal boom that can be raised and lowered. As the rotating wheel is lowered into the ground, the buckets excavate and move dirt in one continuous stream. Once reaching the highest point on the boom, the dirt drops out of the bucket and is deposited to either side of the machine at a predetermined distance from the trench. This is done by a chute attached to an adjustable spoil conveyor that runs laterally to the wheel.

Figure 16-2 – Wheel ditcher.

1.1.2 Ladder Ditcher

Like the wheel ditcher, the ladder ditcher is also mounted on crawler tracks (*Figure 16-3*). It works in the same manner as the wheel ditcher except that its buckets are attached to an endless chain referred to as a ladder. The chain travels along the drive sprockets on the boom assembly. Like the wheel ditcher, the ladder ditcher has a chute attached to an adjustable spoil conveyor.

Figure 16-3 – Ladder ditcher.

1.1.3 Chain Ditcher

Chain ditchers are available in various configurations, from walk-behind models to attachments for a skid loader to heavy wheeled tractors. One common configuration is shown *Figure 16-4.* The chain ditcher has teeth attached to a chain similar to a chain saw. The chain teeth pull or drag the cuttings to the surface, rather than lifting them in a bucket. The cuttings are usually moved back from the edge of the ditch by rotating augers.

Chain ditchers are ideal for lightweight work, such as sprinkler systems, gas lines, and small waterlines. Some of these machines can dig up to 10 inches wide and 4 feet deep.

Figure 16-4 – Chain ditcher on a skid steer.

Test your Knowledge (Select the Correct Response)

1. Which of the following ditchers is ideal for light work, such as small waterlines?

   A. Wheel ditcher
   B. Ladder ditcher
   C. Chain ditcher
   D. Blade ditcher

2.0.0 MAJOR COMPONENTS

Major components and controls on ditchers vary with make, model and configuration. You are responsible for reading the operator's manual for specific information.

The most common type of ditcher the NCF uses is the ladder ditcher; therefore, *Figure 16-5* shows the major components on a Vermeer T-600D ladder ditcher.

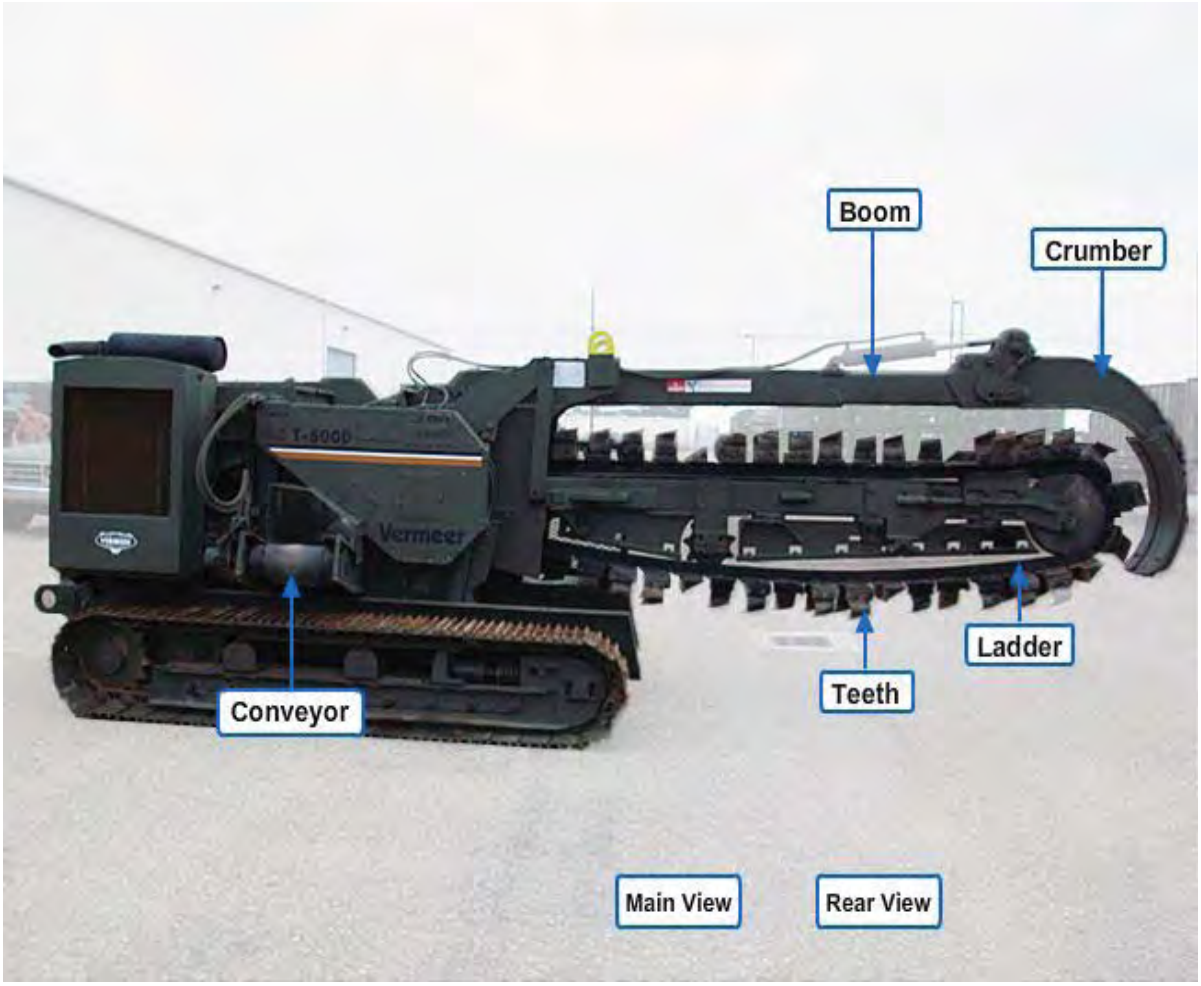


Figure 16-5 – Major components.

2.1.0 Operator's Control Console

Located along the front-end of the ditcher, all of controls and gauges make up the operator's control console. The operator sits facing the console and side of the boom, right above the left track. Newer ditchers have fully enclosed operator's cabs with rollover protective structures (ROPS).

2.2.0 Boom

The operator controls the depth of the trench by hydraulically raising and lowering the boom. On some ladder ditchers, the boom cannot be lowered below 35° from vertical.

2.3.0 Ladder

The ladder is an endless chain which the buckets are attached to. The ladder assembly is lowered into the ditch by the boom.

2.3.1 Bucket Teeth

All ditchers have bucket teeth, which aid in cutting the earth and determine the width of the trench. *Figure 16-6* shows two examples of teeth patterns normally used. When the teeth wear down about one-half inch and before the face of the bucket shows wear, be sure to reverse or replace the teeth.

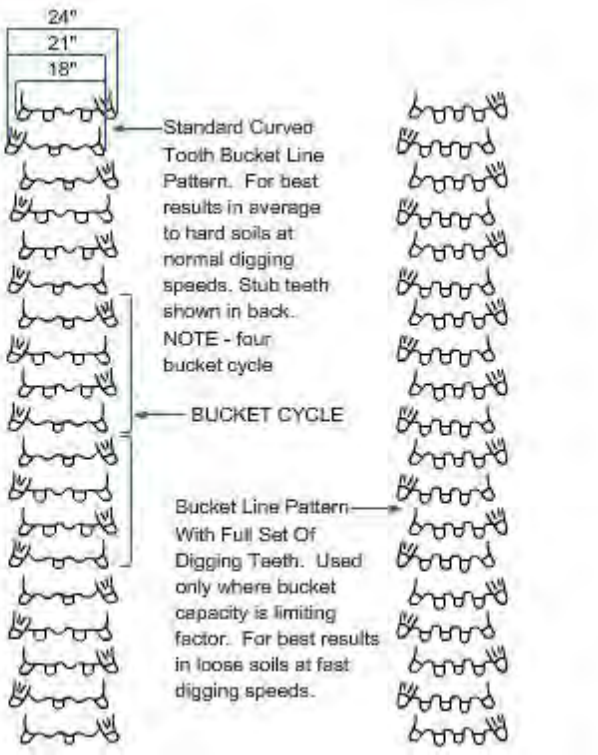


Figure 16-6 – Two basic bucket teeth designs.

NOTE

Always install a complete set of teeth on a bucket when reversing or replacing teeth.

If only a few new teeth are installed here and there along the bucket line, the new teeth will cut the most and wear down much faster than would a whole new set. However, if only one or two teeth show too much wear or are broken or chipped, they may be reversed or new ones installed in their place if the rest of them are in good shape.

2.4.0 Conveyor

Two levers control the speed, direction, and distance (from the trench) to which the conveyor deposits excavated material.

2.5.0 Crumber

The adjustable crumber, serves as a follow-up scraper. It cleans and smoothes the bottom of the trench by filling in holes and by using its hardened tip to pull loose material (“crumb”) back into the bucket teeth.

NOTE

When you increase the cutting width, it is necessary to increase the width of the crumber. To do this, add one of the scraper extension plates to the side of the crumber corresponding to the side of the bucket line on which the side cutters have been added.

Test your Knowledge (Select the Correct Response)

2. **(True or False)** Always install a complete set of teeth on a bucket when reversing or replacing teeth.

   A. True
   B. False

3.0.0 CONTROLS

The typical ditcher has several levers to control the speed and direction of the conveyor and machine as well as the movement of the boom. *Figure 16-7* shows such levers on a T-600D ditcher.

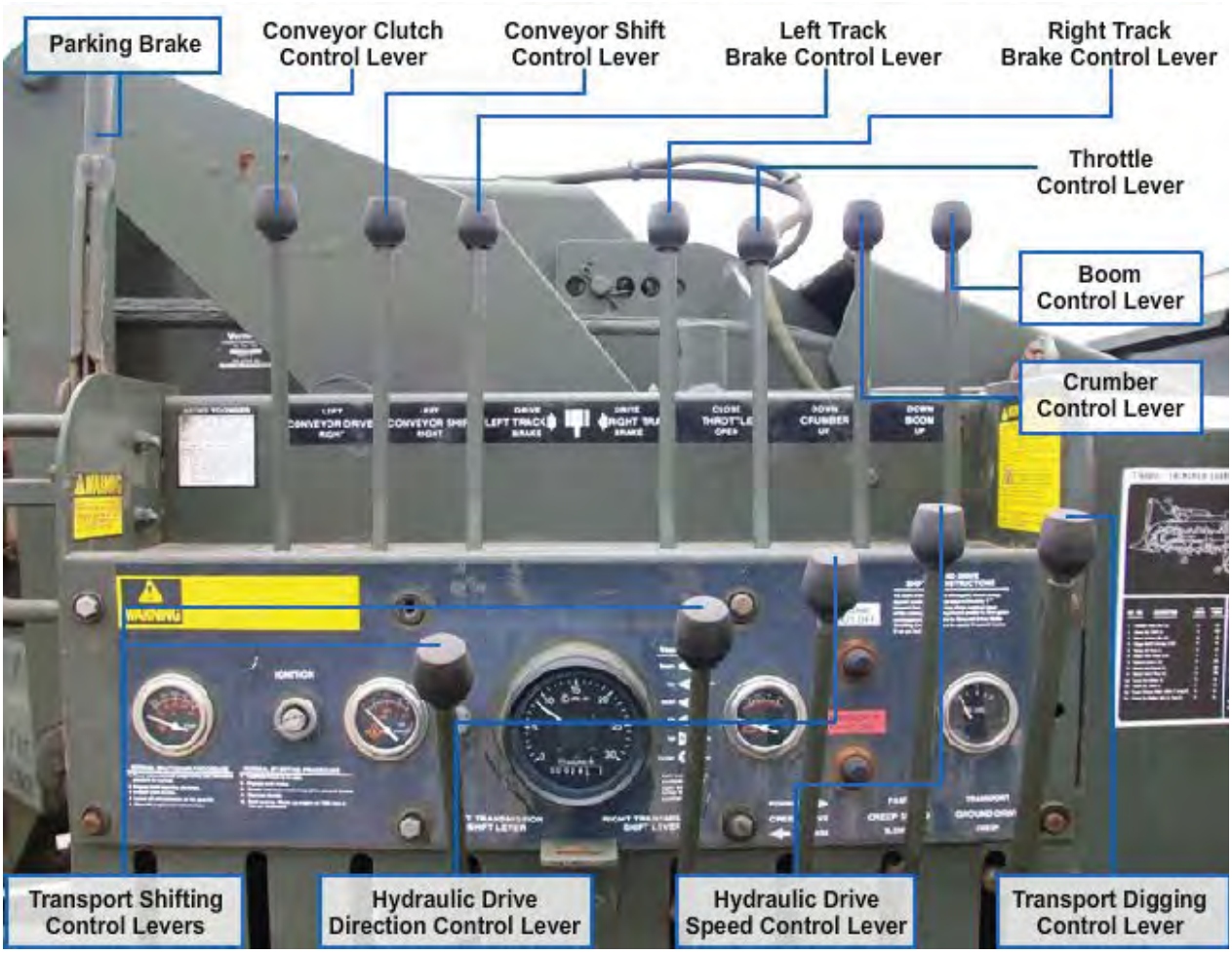


Figure 16-7 – Controls.

3.1.0 Conveyor Clutch Control Lever

The conveyor clutch control lever controls the speed and direction the ditcher deposits excavated material.

- To deposit spoil on the left side of the machine, push the conveyor clutch control lever forward.
- To deposit spoil on the right side, pull the lever back.
- To increase or decrease the speed of the conveyor, move the lever forward or back.

- When the lever is in the center position, the conveyor belt is stationary

3.2.0 Conveyor Shift Control Lever

The conveyor shift control lever allows the operator to position the spoil pile at a desired distance from the trench.

- To shift the conveyor assembly to the left, push the conveyor shift control lever forward.
- To shift right, pull the lever back.
- When the lever is released, it will return to the center position, holding the conveyor assembly in the selected position.

3.3.0 Left and Right Track Control Levers

The left and right track control levers engage and disengage the clutches.

- To engage the clutch, push either lever forward. Depending on the position of the transmission shift lever or the hydraulic drive control levers, the tracks will travel forward or in reverse.
- To disengage the clutch, pull either lever back and apply the brake.

3.4.0 Crumber Control Lever

The crumber control lever raises and lowers the crumber. It works in conjunction with a diverter valve control lever that directs oil to either crumber fold cylinder or the crumber shoe cylinder.

- To raise the crumber, push the diverter valve control up and pull the crumber control lever back.
- To lower the crumber, push the diverter valve control up and push the lever forward.
- To lock the crumber in the lower position, pull the diverter valve control down and push the lever crumber control lever forward.

3.5.0 Boom Control Lever

The boom control lever raises and lowers the boom.

- To lower the boom, push the boom control lever forward.
- To raise the boom, pull the lever back.
- When released, the lever will return to neutral, stopping the movement of the boom.
- When digging on grade, move the boom by applying short, quick jabs, rather than a slow, steady push.

3.6.0 Transport-Digging Control Lever

The transport-digging control lever places the ditcher in either transport or digging mode.

- In the transport mode, the tracks are powered by the transmission and the digging ladder is not powered.
- In the digging mode, the tracks are powered by the hydraulic creep motor and the digging ladder is powered through the transmission.

3.7.0 Hydraulic Drive Speed Control Lever

The hydraulic drive speed control lever controls the creep speed when the ditcher is in digging mode.

- To increase creep speed, push the hydraulic drive speed control lever forward.
- To decrease speed, pull the lever back.

3.8.0 Hydraulic Drive Direction Control Lever

The hydraulic drive direction control lever controls the travel direction of ditcher while in digging mode.

- To travel forward, push the hydraulic drive direction control lever forward.
- To travel in reverse, pull the lever back.

Test your Knowledge (Select the Correct Response)

3. What action must an operator take to deposit spoil on the left side of the ditcher?

   A. Push the conveyor clutch control lever forward
   B. Pull the conveyor clutch control lever back
   C. Push the conveyor shift control lever forward
   D. Pull the conveyor shift control lever back

4.0.0 CAPABILITIES AND LIMITATIONS

A ditcher can dig earth material ranging in texture from soft to hard; however, as the material increases in hardness, the production rate decreases. *Table 16-1* gives maximum trenching rates for classes of soils in feet per minute.

Table 16-1 – Crawler ditcher maximum trenching rates.

PRODUCTION IN FEET PER MINUTES					
DEPTH OF TRENCH	DRY TO MOIST SAND	SOFT DRY CLAY	MOIST CLAY	HARD CLAY & GRAVEL	STICKY CLAY
1 ft. 6 in.	32	28	26	22	16
2 ft.	25	22	20	17	12
2 ft. 6 in.	20	18	16	14	10
3 ft.	16	15	13	11	8
3 ft. 6 in.	14	13	11	10	7
4 ft.	12	11	10	8	6
4 ft. 6 in.	11	10	9	7	5
5 ft.	10	9	8	6	4

A limitation of a wheel, ladder, or chain ditcher is that they leave ramps at the bottom of the trench ends and around buried objects. To obtain a flat-bottom trench, you must remove these ramps by hand. The wheel ditcher digs faster in dense material and is preferred for cross-country digging where speed is needed.

Test your Knowledge (Select the Correct Response)

4. In sticky clay, how many minutes will it take to dig a trench that is 2 feet in depth?

   A. 8
   B. 10
   C. 12
   D. 16

5.0.0 OPERATIONS

In most ditching work, keep the ditcher in line and working at the proper depth. You must use surface controls because you will be unable to see the ditch bottom,

EAs survey the ditch and determine the depth of cut from blueprints. You, the EO, establish a guideline at a fixed and constant distance above the bottom grade of the trench and offset from the center line of the trench beyond the track line of the ditcher.

Establish the guidelines at a height that will put it at least a few inches above the ground at all points, drive stakes along it, and mark the exact height or depth of the cut. Then stretch a string line along the stakes on these markings.

Fasten a rigid bar to the front of the power unit of the ditcher with one end over the string when the ditcher is centered on the ditch line. Fasten a plumb bob or other weight to the bar, so it hangs directly over the string. You can then keep the machine on center of the trench, cut by keeping the plumb bob just over the string. If the ground is irregular and causes the ditcher to go up and down, run the cord holding the plumb bob through eyes or pulleys, so you can reach an end of the cord to raise and lower it.

The same device (plumb bob or other weight) can be fastened on the side beam of the boom or wheel with a fixed length of string to control the depth of cut and center line travel of the ditcher.

5.1.0 Digging with a Wheel Ditcher

To start a cut, lower the rotating wheel into the ground, and then watch the bucket teeth start to dig. As the ditcher itself is stationary, apply enough pressure to the buckets so they fill “heaping” without gouging deeply enough to slow the wheel.

The ditch will have a rounded beginning. Be sure the position of the center of the wheel is over the starting point for the full depth of the ditch, so the ditcher has enough room to dig down to the desired depth at the beginning of the cut. *Figure 16-8* shows these instructions.

Figure 16-8 – Starting a cut with a wheel ditcher.

NOTE

Before starting any excavation, you must be sure to obtain a valid digging permit that covers the area you are tasked to ditch.

5.1.1 Digging

When the wheel is at the correct depth, move the machine forward just fast enough to keep the buckets reasonably full. Crowding too hard overworks the engine and strains the digging parts without adding to the output.

Soft rock usually responds best to high wheel speed with very slow walking speed. If dirt is soft, crowd it so the dirt in excess of the bucket capacity piles on each side of the ditch without damage.

Experience will help when selecting the right combination of digging and travel speeds for various types of soil; however, consult the operator’s manual for guidance on digging and travel speeds for the type of ditcher used.

5.1.2 Obstructions

Where you could meet boulders, heavy roots, or pipelines, adhere to the following guidelines:

- Both walking and wheel speeds should be slow.
- The teeth cut through soft boulders. Depending on how buried a hard boulder is, the teeth may pull it to the surface or force it forward. This is because the deeper boulder not only is held down by a greater weight of dirt but also the direction of the tooth contact tends to force it forward, rather than up.
- The wheel will usually ride over embedded boulders the ditcher cannot remove. If a large boulder is near the surface of the cut, it may stop the forward motion of the machine; in which case, cut the power off promptly.
- If a boulder is pulled to the surface, it may land in an inconvenient spot, forward of the wheel and between the tracks. You may have to lift the wheel into transporting position, work forward until clear of the rock, push it out of the way, and back up until the wheel can be lowered to the ditch bottom. If the boulder is too large for the wheel to clear, release the wheel drive clutch so the wheel can turn as it is pulled over the boulder.
- When the wheel is lifted above grade to clear any obstruction, you may work it back to grade at the other side in the same way you started the cut.
- Turn with caution while digging. Slight turns cause the wheel to move sideways in the trench. If the buckets have long side teeth or side-cutting bars and the earth is soft, you can make a gradual turn without damaging the wheel assembly. Sharp turns may cause severe damage, such as bending the wheel frame, bending the wheel itself, or pulling the wheel frame off the vertical track.

5.2.0 Cutting Curves

The radius of a curve cut while excavating a trench depends mainly on the density of the soil excavated. In sandy or loose soil, the radius can be much less than in hard, compacted, and rocky soil. Make the turns cautiously at a slow digging speed and only to where the boom starts binding between the trench walls.

5.3.0 Muddy Trenching

The two major problems when trenching in muddy materials are loss of traction and a buildup of material in the buckets. You can increase the traction by putting planking under the tracks or by adding wider crawler pads. To cope with material sticking to the teeth and buckets, you can run the digging chain faster, so the material will not be forced into the cut. In this way, you do not force and pack wet, sticky material into the bucket and between the teeth; otherwise, the material in the bucket gets stuck and cannot empty completely.

5.4.0 Transporting

A ditcher is slow and must be hauled between jobsites. It must be loaded and unloaded safely and properly. The design of the ditcher requires that it be used on a smooth, gradual incline. When loading on a tilt-bed trailer, you must be careful; the sharp incline of the trailer could make the ditcher hang up. Additionally, the smooth tracks of the ditcher tend to slip.

The combination of the ditcher design, brakes, and smooth tracks makes it almost impossible to stop on an incline while loading or unloading; therefore, it is important to use a proper ramp or loading platform to load the ditcher. For safety, load and unload the ditcher in low gear, and if you do not have a proper ramp, see that a crane is used to load and unload the ditcher.

Test your Knowledge (Select the Correct Response)

5. **(True or False)** Crowding too hard overworks the engine and strains the digging parts without adding to the output.

   A. True
   B. False

6.0.0 SAFETY

The following are standard safety precautions for ditchers:

- Do NOT leave the operator's seat unless you have stopped the ditcher and disconnected all power from the engine to the ditcher.
- Do NOT engage the engine clutch too fast. Let it engage gradually to prevent damage to the gear cases and other moving parts.
- Do NOT fill the fuel tank with the engine running.
- Do NOT let bolts and keys come loose. Be alert for unusual sounds or odors. These are danger signs and should be investigated to prevent downtime.
- When the ditcher is secured, the bucket line must always be raised clear of the trench. Ditches left open must be flagged by day and properly lighted at night.
- Do NOT let anyone work or stand close to the digging boom. In a cave-in, the person might be pulled into the boom or other moving parts. Also, if an electrical line is hit, people standing nearby could be hurt.
- Before digging, be sure you have a digging permit. You should know and have marked all underground obstructions.
- Never try to remove an object from the conveyor belt while the conveyor is running.
- Never raise the boom of the ditcher more than you have to while on an incline, because the ditcher is easily upset.
- Wear the required personal protective equipment, such as steel toe shoes, hard hat, and gloves.

Test your Knowledge (Select the Correct Response)

6. **(True or False)** It is a safe practice to NOT allow someone to stand to close to the digging boom.

   A. True
   B. False

Summary

The ditcher is a piece equipment that the NCF uses for digging trenches for underground utilities and conduits.

In this chapter you were introduced to three types of ditchers: wheel, ladder and chain. Because the ladder ditcher is the most common, you were introduced to it's a major components including boom, ladder, and conveyor for depositing excavated material. In addition, you were introduced to its levers for controlling speed and direction. This chapter introduced digging capabilities and limitations in soils. You were introduced to operations such as cutting curves and trenching in mud as well as safety practices to adhere to while performing such operations.

Review Questions (Select the Correct Response)

1. What term is used to describe a temporary cut made in the earth for underground utilities?

   A. An excavation
   B. A ditch
   C. A trench
   D. A gully

2. On some ladder ditchers, the boom cannot be lowered more than, how many degrees from vertical?

   A. 15°
   B. 25°
   C. 35°
   D. 45°

3. **(True or False)** The chain teeth on a chain ditcher are used to cut and lift the cut material to the surface.

   A. True
   B. False

4. Which of the following ditchers is most commonly used in the NCF?

   A. Wheel
   B. Ladder
   C. Chain
   D. Blade

5. Bucket teeth should be reversed or replaced when the teeth wear down to approximately what length?

   A. 1/2 inch
   B. 1 inch
   C. 1 1/2 inches
   D. 2 inches

6. What component on a ladder ditcher cleans and smoothes the bottom of the trench?

   A. Bucket teeth
   B. Crumber
   C. Stinger
   D. Conveyor

7. In digging mode, what powers the ladder?

   A. Transmission
   B. Hydraulic motor
   C. Creep motor
   D. Auxiliary transmission

8. Which of the following ditchers digs faster in dense material and is preferred for cross-country digging where speed is needed?

   A. Wheel
   B. Ladder
   C. Chain
   D. Blade

9. Before starting any ditcher excavation project, the operator must attain what type of permit that covers the area to be excavated?

   A. Excavation
   B. Ditching
   C. Digging
   D. Trenching

10. The radius of a curve cut while excavating a trench depends mainly on what factor?

    A. The density of the soil excavated
    B. The type of ditcher
    C. The type of teeth
    D. The radius turn

11. What are two major problems when trenching in muddy materials?

    A. Crowding and stain on digging parts
    B. Material build-up and flotation
    C. Traction and material build up
    D. Traction and flotation

12. **(True or False)** A ditcher can be stopped on an incline while it is being loaded or unloaded.

    A. True
    B. False

13. **(True or False)** The ditcher should be in low gear when it is loaded or unloaded.

    A. True
    B. False

14. **(True or False)** It is a safe practice to remove object from the conveyor belt while the conveyor is running.

A. True
B. False

Additional Resources and References

This chapter is intended to present thorough resources for task training. The following reference works are suggested for further study. This is optional material for continued education rather than for task training.

Ditcher Operations, SCBT 548.1, Naval Construction Training Center, Gulfport, MS, 1985.

Operator's Manual: T-600D Trencher, Vermeer Manufacturing Company, Pella, IA, 1986.

CSFE Nonresident Training Course – User Update

CSFE makes every effort to keep their manuals up-to-date and free of technical errors. We appreciate your help in this process. If you have an idea for improving this manual, or if you find an error, a typographical mistake, or an inaccuracy in CSFE manuals, please write or email us, using this form or a photocopy. Be sure to include the exact chapter number, topic, detailed description, and correction, if applicable. Your input will be brought to the attention of the Technical Review Committee. Thank you for your assistance.

Write: CSFE N7A
3502 Goodspeed St.
Port Hueneme, CA 93130

FAX: 805/982-5508

E-mail: CSFE_NRTC@navy.mil

Rate____ Course Name_____

Revision Date_____ Chapter Number____ Page Number(s)_____

Description

_____

_____

_____

(Optional) Correction

_____

_____

_____

(Optional) Your Name and Address

_____

_____

_____

Chapter 17

Graders

Topics

To hear audio, click on the box. 

Overview

As an Equipment Operator, you will use a grader to cut and move material for final shaping and finishing.

This chapter provides the information needed to successfully perform such operations. It describes the types of grader used by Naval Construction Force (NCF) and includes descriptions of major components, controls, and attachments. In addition, this chapter explains how to wheel lean and turn around, as well as cut V-type and flat bottom ditches. Lastly, it lists safety practices.

Objectives

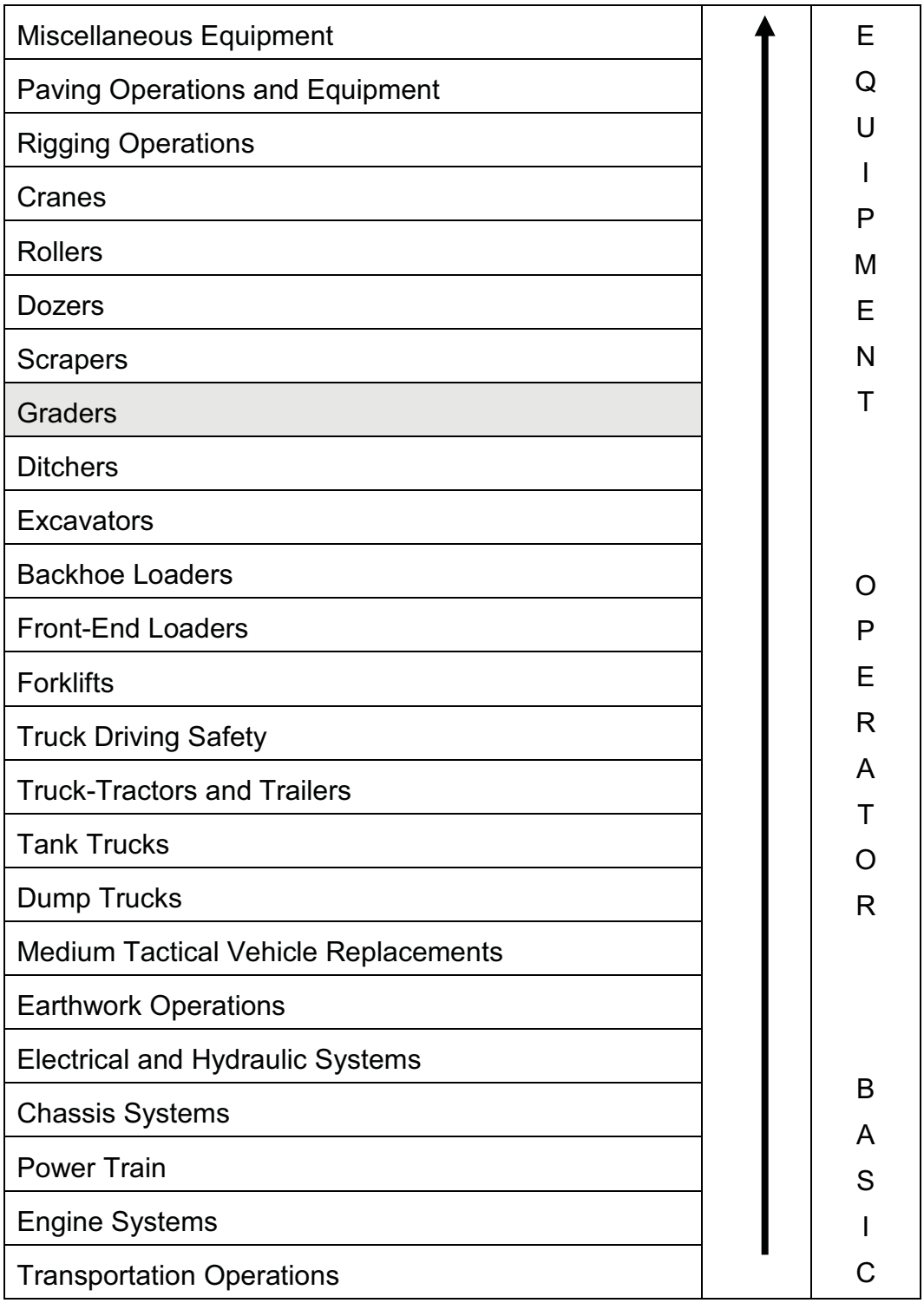
When you have completed this chapter, you will be able to do the following:

1. Understand the use of graders.
2. Identify the major components of graders.
3. Identify the controls on the grader.
4. Understand the use of a ripper attachment.
5. Understand how to perform grader operations.
6. Understand grader safety.

Prerequisites

None

This course map shows all of the chapters in Equipment Operator Basic. The suggested training order begins at the bottom and proceeds up. Skill levels increase as you advance on the course map.



Features of this Manual

This manual has several features which make it easy to use online.

- Figure and table numbers in the text are italicized. The figure or table is either next to or below the text that refers to it.
- The first time a glossary term appears in the text, it is bold and italicized. When your cursor crosses over that word or phrase, a popup box displays with the appropriate definition.
- Audio and video clips are included in the text, with italicized instructions telling you where to click to activate it.
- Review questions that apply to a section are listed under the Test Your Knowledge banner at the end of the section. Select the answer you choose. If the answer is correct, you will be taken to the next section heading. If the answer is incorrect, you will be taken to the area in the chapter where the information is for review. When you have completed your review, select anywhere in that area to return to the review question. Try to answer the question again.
- Review questions are included at the end of this chapter. Select the answer you choose. If the answer is correct, you will be taken to the next question. If the answer is incorrect, you will be taken to the area in the chapter where the information is for review. When you have completed your review, select anywhere in that area to return to the review question. Try to answer the question again.

1.0.0 GRADERS

Graders, like the one shown in *Figure 17-1*, are long, narrow, multipurpose machines used primarily for general construction and maintenance of roads and runways. Equipped with an adjustable moldboard, similar to a blade, graders can be used for rough and finish grading and creating ***side casting*** windrows, which are long narrow piles of materials.

Figure 17-1 – Grader.

Additionally, graders can be used for crowning and leveling roads, mixing and spreading materials, ditch cutting and ***bank*** sloping, snow removal, and ***scarifying***. *Figure 17-2* shows a runway that a grader cleared of ash after the eruption of a volcano.

Figure 17-2 – Cleared runway.

Graders are rubber-tired hydraulically operated, single-engine units. The single-engine provides power for all grader functions.

Although graders, at times, must be hauled to and from jobsites, graders have an advantage over other heavy equipment because of their capability to travel over the road under their own power.

NOTE

When hauling a grader with a tractor-trailer, ensure the height of the grader cab clears all overhead obstacles.

1.1.0 Types of Graders Used by Naval Construction Force

The NCF uses a variety of makes and models of graders, most of them have articulated-frames, some have conventional rigid-frames.

1.1.1 Articulated Frame

Graders with an articulated frame have a hinge or pivot point located in the frame, just forward of the engine. A pair of hydraulic cylinders, one on either side the frame control articulation. Such a design allows for an increase in productivity and stability. Compared to rigid frames, articulated frames allow for shorter turning radius, easier maneuvering in close quarters, and quick turnaround at the end of a pass and enable the grader to carry a full blade of material around a curve.

Articulated frames also allow for crab steering, which helps compensate for side drift when turning a windrow, keeps tandems on a firm footing when clearing ditches, and increases stability on side slope work. *Figure 17-3* demonstrates articulation as well as crab steering.

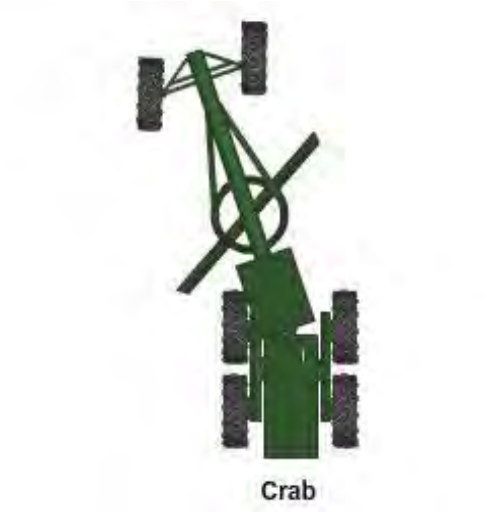


Figure 17-3 – Articulating grader.

Like other construction equipment with articulated frames, graders have lock pins installed to prevent articulation during transportation.

NOTE

Before articulating the grader, be aware of the position of the grader blade. With the blade angled in an acute position, articulating the grader sharply can position the rear tires to run into the blade.

Test your Knowledge (Select the Correct Response)

1. Which of the following operations is NOT performed by a grader?

   A. Ditch cutting
   B. Crowning
   C. Side casting
   D. Trenching

2. **(True or False)** The pivot point on a grader is located in front of the operator's cab.

   A. True
   B. False

2.0.0 MAJOR COMPONENTS

Regardless of make and model, graders have basically the same major components. *Figure 17-4* shows the major components of a Caterpillar 135H.

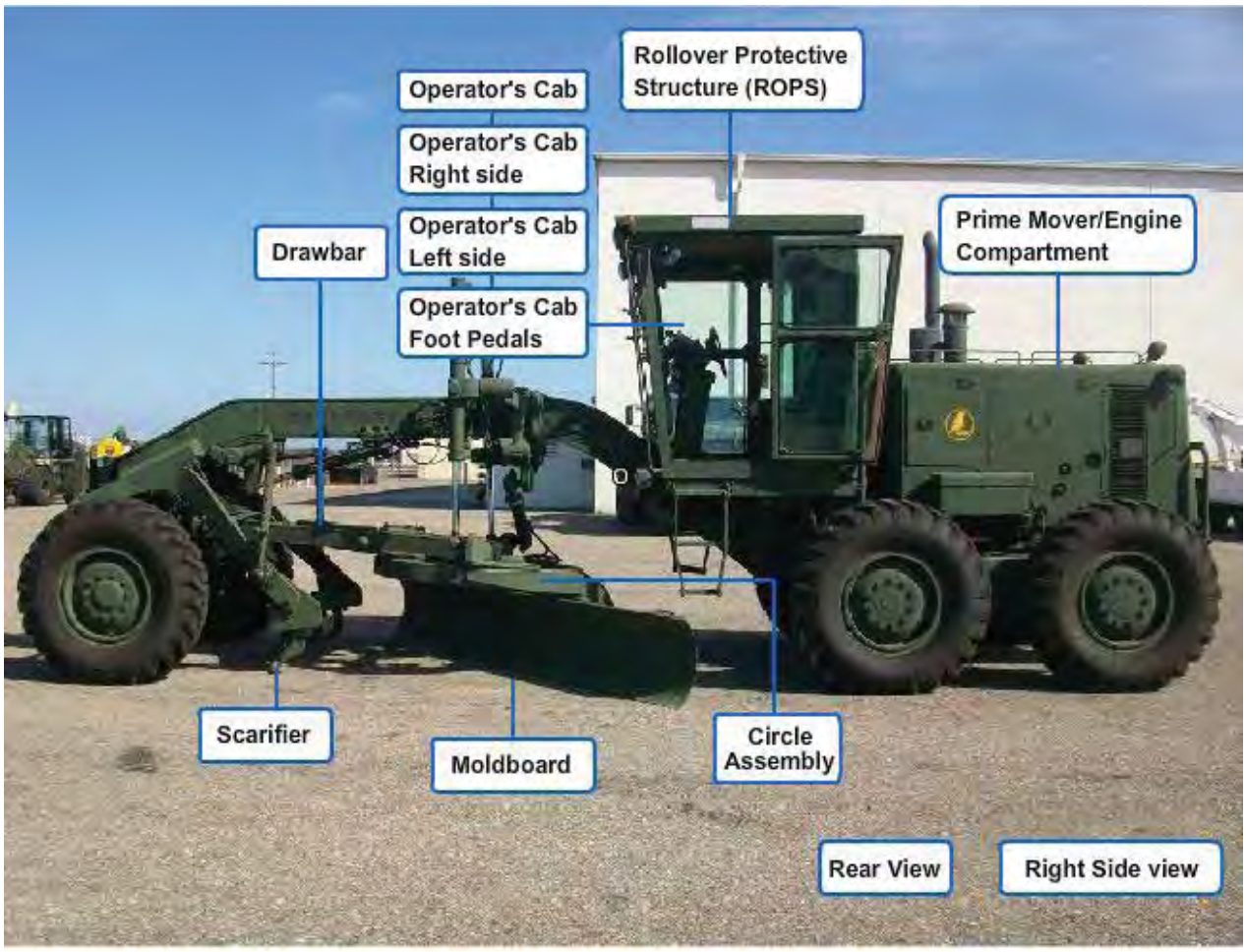


Figure 17-4 – Major components.

2.1.0 Operator's Cab

The operator's cab houses the instrument panel and controls, including the steering wheel and the levers to move the machine and perform grader operations. Enclosed by a windshield and large windows, it provides maximum visibility and protection against harsh weather.

2.2.0 Prime Mover

The prime mover is a rubber-tired tractor, powered by a 6- to 12-cylinder diesel engine mounted at the rear over the driving wheels for increased traction. The prime mover has four-rear mounted single tires driven in tandem drive through gears and chains and a single-steering axle.

2.2.1 Tandem Drive

The grader's tandem drive allows climbing over rocks, logs, or humps and permits passing through depressions and ditches one wheel at a time, as shown in *Figure 17-5*. Because the grader has this capability, one rear wheel can raise or lower, while the other remains on the same level with the front wheels, thereby holding the grader on a level terrain. This is a very important feature. If the rest of the grader does not rise and fall while operating over uneven terrain, the moldboard does not vary in elevation. Depending on the specific operation, the end result is an even cut, spread, or uniform side cast.

Figure 17-5 – Tandem drive.

2.3.0 Frame

The frame connected to the front axle extends the full length of the grader and is high enough to allow space for carrying and manipulating the working tool.

The front axle is compound. The lower section carries the weight of the grader, oscillates on a center pin, and is hinged to the bottom of the wheel spindle. The upper section of the axle is hinged to the top of the spindle, allowing the front wheels to lean left or right, as well as turn, as shown in *Figure 17-6*.

Figure 17-6 – Wheel lean.

2.4.0 Moldboard

The moldboard, also called the blade, is the grader's working tool. Generally, 12 or 14 feet in length, the moldboard consists of a bolted-on cutting edge and end bits. The cutting edge is attached to bottom of the moldboard, while the end bits are attached to each side. They act as wear plates, protecting the moldboard, and must be replaced or reversed when worn or broken. In most cases, the bolts will also have to be replaced.

NOTE

Always keep enough cutting edges and end bits on hand to protect the moldboard from wear or damage.

The position and pitch of the moldboard can be hydraulically manipulated. It can be positioned perpendicular to the direction of travel, to push material forward, or angled to create and side cast windrows.

When the moldboard is angled to the direction of travel, the terms "heel" and "toe" are used to identify the ends of the moldboard. The leading end, closest to the front wheels, always referred to as the "toe", while the trailing end, closest to the rear wheels, is referred to as the "heel". When blade is turned and the toe is to your left, as you sit in the operator's seat, the material will be side cast to your right and spill off the heel, creating a windrow. This is known as left-hand grading. When the toe is one the right, the windrow will side cast to the left and spill off the heel, creating a windrow. This is known as right-hand grading. *Figure 17-7* shows both left- and right-hand grading.

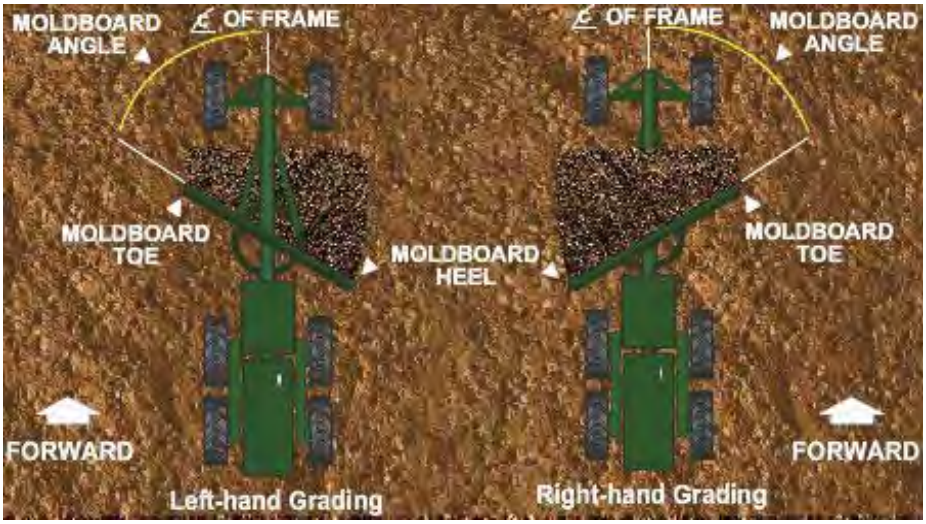


Figure 17-7 – Left- and right-hand grading.

The moldboard can be rotated 360 degrees in either direction. This allows an experienced operator to save time by grading while the machine travels backwards with a blade positioned at 180-degrees, a technique called reverse blading.

The moldboard can also be shifted left or right to gather material on either side of the grader or lowered and raised to affect the depth of the cut. As it cuts, the moldboard can be tilted forward to roll and mix material or tilted back for greater cutting action.

The moldboard is supported and held in position by curved brackets, called circle knees and side shift guides, which are attached to the underside of a rotatable ring, called the circle.

2.5.0 Circle Assembly

The circle is a tooth-ring gear that is rotated in a supporting frame by the circle reverse mechanism. Depending on the make and model of the grader, the circle teeth may be internal or external. In the case of the Caterpillar 135H, the teeth are internal.

The circle is turned by a spur-pinion gear that meshes with the circle teeth. The spur-pinion gear is held by the drawbar and controlled by a lever in the operator's cab. By engaging the spur-pinion gear, the circle and moldboard can rotate 360 degrees in either direction.

2.6.0 Drawbar

The drawbar is a V- or T-shaped connection between the front of the grader frame and the circle. A V-shaped drawbar was shown earlier in *Figure 17-4*.

The drawbar holds the circle rigid and is fastened by a ball and socket that allows angular movement from side to side and up and down (*Figure 17-8*). The drawbar carries the full-horizontal load on the moldboard. Other components provide vertical and side support.

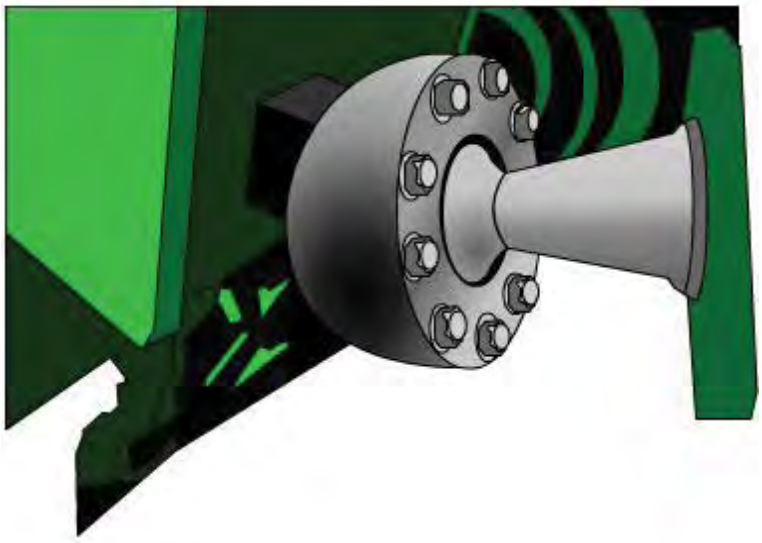


Figure 17-8 – Ball-and-socket connection.

2.7.0 Scarifier

Located in front of or behind the front wheels, the scarifier is a hydraulically controlled unit with a set of teeth used to break up surfaces too compacted for the moldboard to penetrate. Depending on the make and model of the grader and its position on the grader, the scarifier can be either pulled or pushed through the material.

The teeth, consisting of slender shanks with replaceable caps, are arranged in a “V” or in a straight line. The shanks are wedged or clipped in place and can be adjusted for height or removed completely.

Use a scarifier with a complete set of teeth for shallow penetration and light work. For hard or deeper penetration, remove every other tooth.

During a pre-start check on a grader, check the scarifier’s teeth for wear. When the caps are worn enough to cause damage to the shank, replace the cap.

Test your Knowledge (Select the Correct Response)

3. What component restricts the moldboard from varying in elevation over uneven terrains?

   A. Prime mover
   B. Tandem drive
   C. Frame
   D. Circle assembly

4. When the moldboard is angled perpendicular to the direction of travel, its leading end is referred to as the _____.

   A. Toe
   B. Heel
   C. End bit
   D. Cutter

3.0.0 CONTROLS

Grader operations involve using levers located on the left and right side of the steering wheel. The Caterpillar 135H grader has a total of nine levers, as shown in *Figure 17-9*. Stamped with their individual function, most of these levers have three positions; forward, center, and back. In most cases, when they are released from the forward or back position they will return to the center position, suspending the specific movement of the grader.

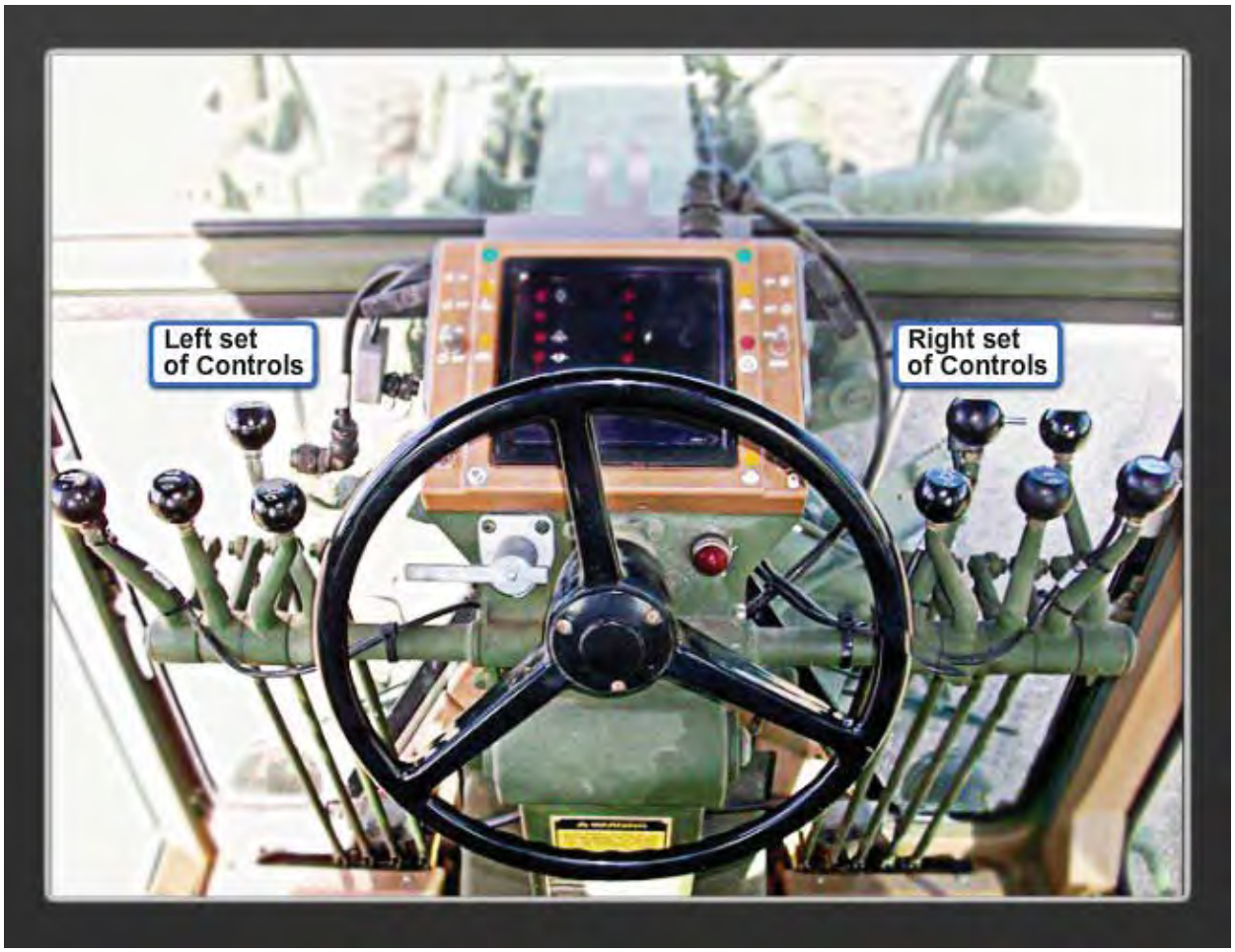


Figure 17-9 – Controls.

3.1.0 Blade Lift Controls for the Left and Right Side

The blade lift controls raise and lower the left or right end of the blade. They can be used one at a time or together to raise or lower the entire blade. Both controls have four positions; back, center, slightly forward, and completely forward.

- To raise either the left or right end of the blade, pull its corresponding lift control back.
- To lower either end, slightly push its corresponding lift control forward.
- When released from either the lift or lower position, the control will return to the center position, where it will hold the blade in its position.
- To place the blade in the float position, completely push the lever forward. The lever will remain in this position, even after being released.

3.2.0 Blade Sideshift Lever

The blade sideshift lever moves the blade left or right.

- To move it to the left, push the blade sideshift lever forward.
- To move the blade right, pull the lever back.

3.3.0 Blade Circle Drive Lever

The blade circle drive lever rotates the circle clockwise or counterclockwise.

- To rotate the circle clockwise, pull the blade circle drive lever back.
- To rotate it counterclockwise, push the lever forward.

3.4.0 Blade Tip Control Lever

The blade tip control lever tilts the top of blade forward or back.

- To tilt the top of the blade forward, push the blade tip control lever forward.
- To tilt the top back, pull the lever back.

3.5.0 Articulation Control

The articulation control moves the rear of the grader left or right.

- To move the rear of the grader left, push the articulation control forward.
- To move the rear to the right, pull the control back.

3.6.0 Centershift Control

The centershift control moves the drawbar left or right.

- To move the drawbar left, push the centershift control forward.
- To move the drawbar right, pull the control back.

3.7.0 Wheel Lean Control

The wheel lean control tilts the wheels left or right.

- To lean the wheels left, push the wheel lean control forward.
- To lean the wheels right, pull the control back.

3.8.0 Ripper/Scarifier Lever

The ripper/scarifier lever raises and lowers the ripper or scarifier.

- To raise the ripper or scarifier, pull the ripper/scarifier lever back.
- To lower the ripper or scarifier, push the lever forward.

Test your Knowledge (Select the Correct Response)

5. Which of the following controls moves the moldboard left and right?

   A. Blade sideshift lever
   B. Blade circle drive lever
   C. Blade lift lever
   D. Moldboard lever

6. What is the function of the centershift control?

   A. Move the drawbar left or right
   B. Move the ripper left or right
   C. Move the rear of the grader left or right
   D. Position the blade tip

4.0.0 RIPPER ATTACHMENT

A ripper attachment is a claw-like device used for breaking up asphalt, large rocks, and tree stumps. Like the scarifier, it has teeth mounted on shanks; however, the ripper usually has fewer and larger teeth. For heavy ripping, one single shank and tooth can be used. For the most ripping power, the ripper is mounted to the rear of the grader, as shown in *Figure 17-10*.

Figure 17-10 – Ripper.

Test your Knowledge (Select the Correct Response)

7. **(True or False)** For the most ripping power, mount the ripper behind the front wheels of the grader.

   A. True
   B. False

5.0.0 OPERATIONS

Although the grader is a multipurpose machine capable of a variety of jobs, the performance of the grader depends largely upon the skill of the operator. The extensive skill required to be an effective grader operator is gained only through practice and on-the-job experience.

5.1.0 Wheel Leaning

The proper use of the front wheels is a great aid in both steering and grading. In grading, lean the top of the wheels in the direction of the flow of material (the heel of the blade). For example, as shown in *Figure 17-11*, viewed from the operator's seat, the toe of the blade is extended to the right of the grader side, casting the material to the left. The material cut at the toe of the blade causes a pulling force exerted on the front end of the grader, wanting to pull the grader to the right. Leaning the top of the wheels to the left (the heel) counteracts this pulling force.

Figure 17-11 – Proper wheel lean.

Figure 17-12 – Wheel lean on a ditch slope

When grading a ditch foreslope, as shown in *Figure 17-12*, lean the top of the wheels enough to keep them in a vertical working position. This lean technique will keep the grader from drifting down the bottom of the foreslope and the wheels from climbing the walls of the backslope.

On high bank-cutting operations, lean the top of the wheels toward the bank, as shown in *Figure 17-13*. The blade engaged in the bank cut causes a pushing force, wanting to push the grader away from the bank. The wheel lean counteracts the force and helps keep the blade properly positioned for bank cutting.

Figure 17-13 – Wheel Lean on high bank-cutting operations.

5.2.0 Turning Around

When jobs are confined to short stretches or narrow widths, rotating the blade from forward to reverse requires a circle reverse movement of only about 70 degrees, as shown in *Figure 17-14*. When reverse blading, the cut pass is normally made in reverse, while the side casting of the windrow pass is made on the forward trip, saving valuable time and speed in operations by eliminating frequent turning around of the grader.

Figure 17-14 – Changing blade from forward to reverse.

NOTE

Reverse grading is only for operators who have developed superb skills in grader operations.

For reverse blading, if the scarifier unit is located just in front of the blade (behind the front axle), remove all of the scarifier teeth and fully retract the scarifier unit. This allows a clear area when changing the direction of the blade. When reverse blading, set the blade so the toe is just outside of the rear tires, and the heel side casts outside the front tire on the opposite side.

NOTE

Store scarifier teeth in collateral equipage or in a location so they will not be lost. The operator is responsible for all of the scarifier teeth assigned to the grader.

When you are grading on a project where the passes are less than 1,000 feet, it is more efficient to grade in reverse or back the grader the entire distance to the starting point - than it is to turn around and continue work from the far end, as shown in *Figure 17-15*.

Figure 17-15 – Eliminating unproductive turns.

When you are grading on a project where the passes are 1,000 feet or more, it is more efficient to turn the grader around and start blading from the far end back to the starting point, as shown in *Figure 17-16*.

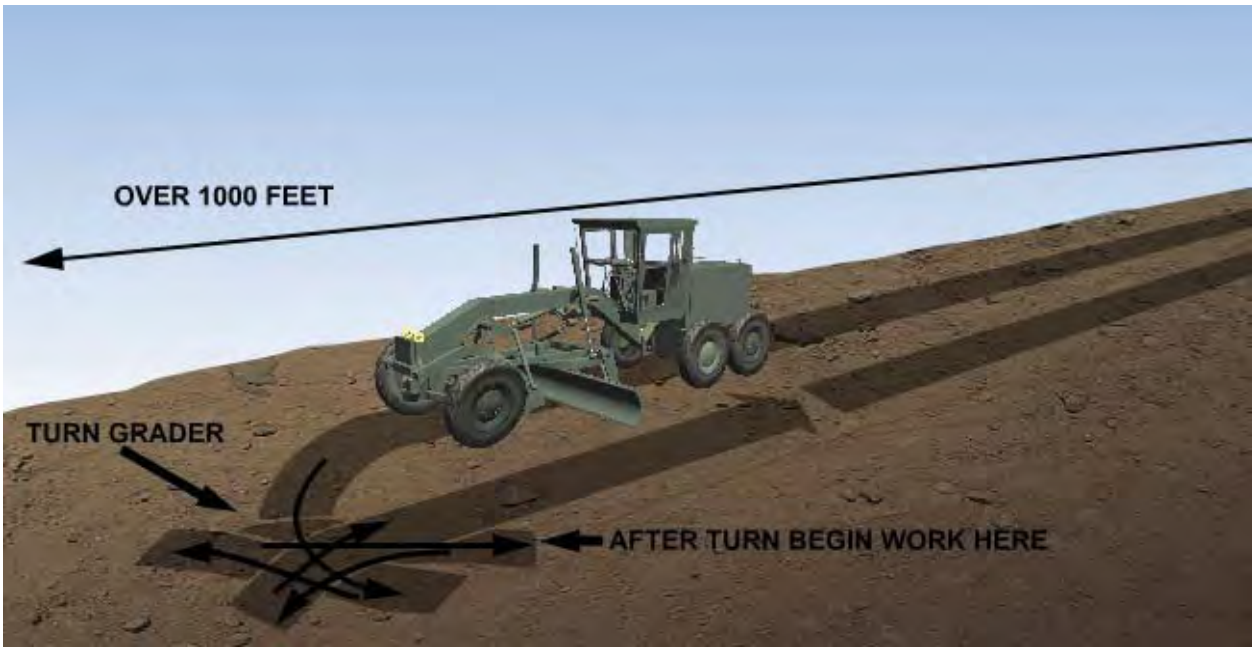


Figure 17-16 – Turning around.

The combined maneuvering advantages of leaning front wheels and rear tandem drive are a big help in turning the grader around on a construction project. *Figure 17-17* shows a simple technique for turning the grader around. With the wheels leaned in the direction of the turn (A), back across the ditch (B), and then complete the turn (C). By keeping the front wheels on the roadway and leaning the wheels in the direction of the turn (D and E), you can make the grader turn with ease.

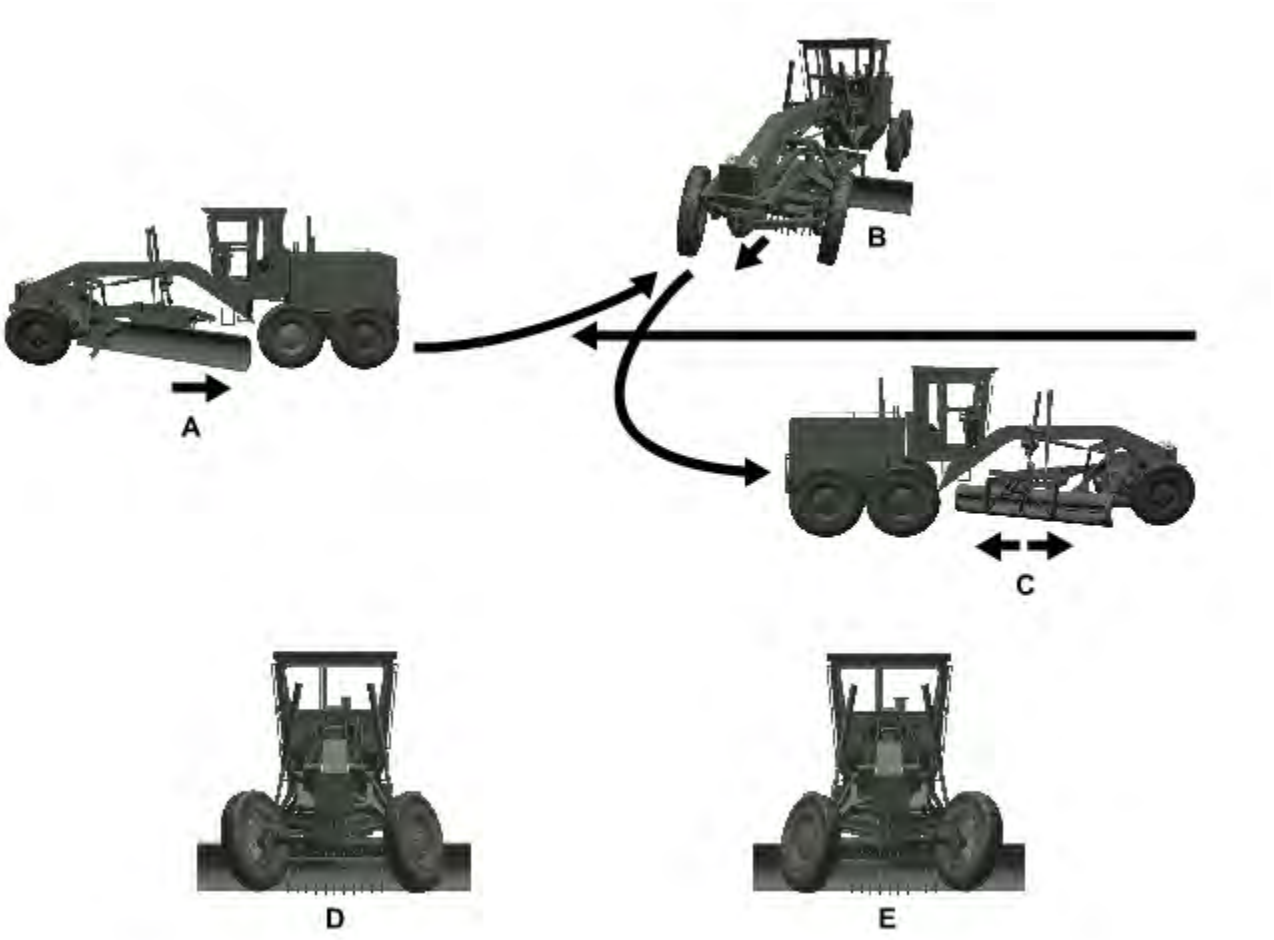


Figure 17-17 – Turning the grader around technique.

NOTE

Always back across the ditch and leave the front wheels on the roadway.

CAUTION

Never make sharp turns with the scarifier teeth in the ground. Making sharp turns damages the scarifier and can bend or break the teeth.

5.3.0 Blade Pitching

The blade pitch adjustment is a working tool that supports the cutting action of the blade and is hydraulically controlled by a lever in the operator's cab. *Figure 17-18* shows the different blade pitch adjustments.

For normal grading operations, the blade is used in the upright position (A). For a greater cutting action, the blade is pitched backward (B). For a greater mixing and rolling action on the material being side casted, the blade is pitched forward (C). For spreading, finishing, or maintaining surface material, the blade is pitched fully forward (D). This pitch accomplishes a partial compaction of the surface materials and ensures filling any low spots.

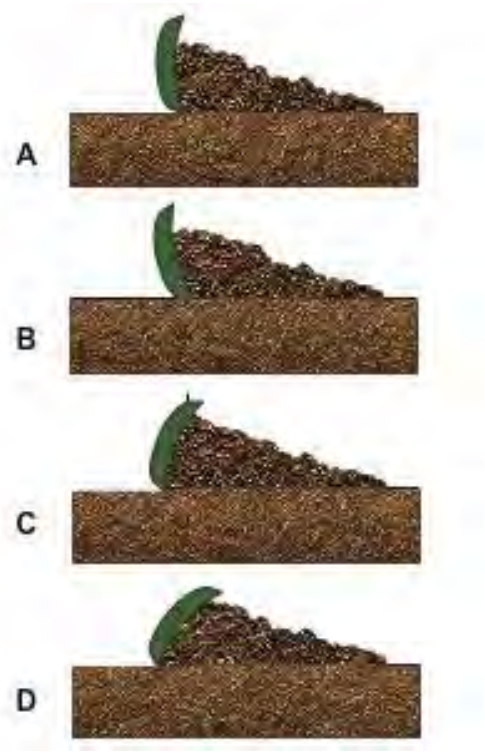


Figure 17-18 – Blade pitching.

When selecting the correct blade pitch, think about the type of operation, type of material, depth of cut, and speed of operation. Experience and practice enhance your skills in achieving the best results for the type material.

5.4.0 Scarifying

Scarifying is the action of breaking up hard or compacted material with the use of a scarifier. Filling ruts and potholes in a dirt road often involves scarifying.

The decision to scarify a road depends on two factors: the availability of water to obtain optimum moisture content of the fill material and the amount of traffic that travels the road. Optimum moisture supports the binding of the fill material (required for compaction) and controls dust.

Placing fill material on a dirt road to fill in ruts and potholes is a temporary fix. The fill material does not bind in the ruts and potholes and, therefore, will not remain in place.

The proper way to reshape a dirt road with ruts and potholes is to scarify its surface to the depth of the depressions. This breaks up all the compacted surrounding surface material. After scarifying the material, blade mix the surface materials, reshape the road, and use a roller to compact the area.

To scarify extremely hard or consolidated material, remove alternate scarifier teeth. This will ease passage of the scarifier through the material.

5.5.0 Ditch Cutting

The first step performed on a road project is to establish drainage, normally through the use of a ditch. To construct a ditch, you must know how to cut a straight ditch line and ensure that the ditch line stakes fit the plans.

The first cut is referred to as the marking cut. The marking cut is a 3- to 4-inch-deep cut made with the toe of the blade *(Figure 17-19).* The toe of the blade is positioned in line with the outside edge of the front tire. For cutting, the blade is in the upright position, aligned perpendicular to the ground. The marking cut is a technique used for easier grader control and straighter ditches.

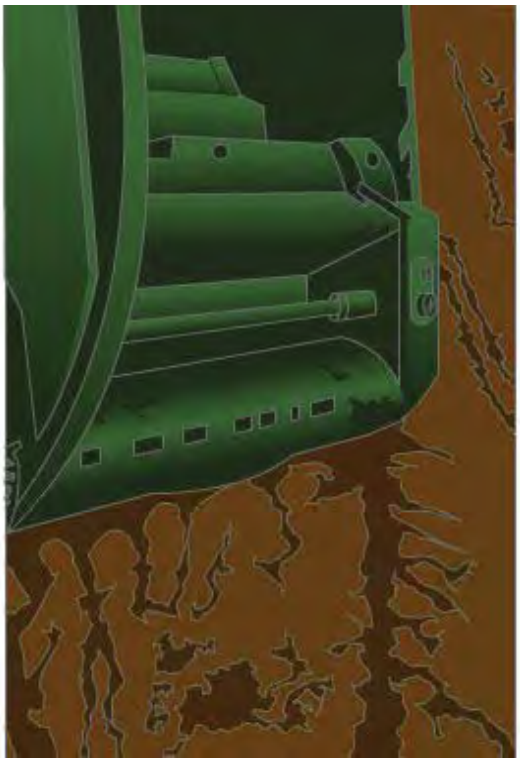


Figure 17-19 – Marking cut.

After the marking cut, position the blade at about a 45-degree angle to perform an efficient ditch cut *(Figure 17-20).* The toe of the blade is now positioned in line with the center of the front tire, while the heel of the blade is raised to allow a windrow to form either inside or outside the rear tires *(Figure 17-21).* Removing the scarifier teeth may be necessary to keep them from interfering with the blade.

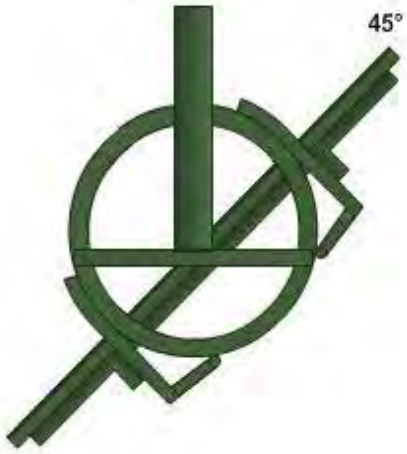


Figure 17-20 – Positioning blade 45-degrees.

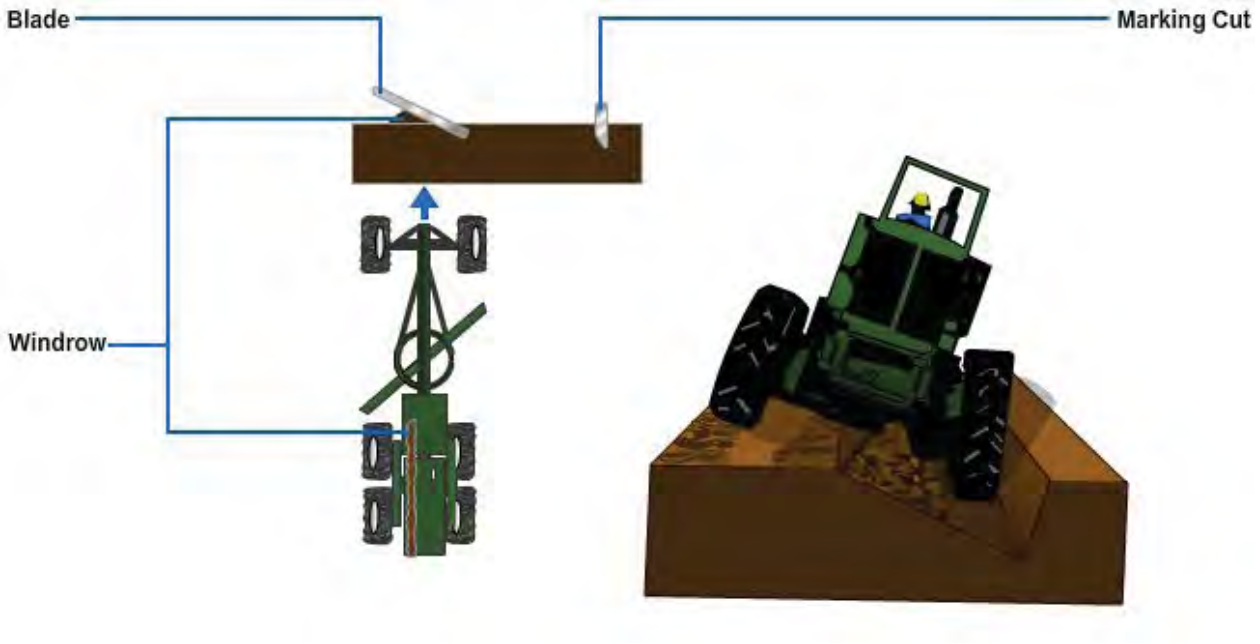


Figure 17-21 – Ditch cut.

NOTE

Do not forget to lean the top of the front wheels in the direction of the flow of the cut material.

After the formation of a windrow, it should be spread towards the middle of the road, away from the ditching operations. This technique is called shoulder pickup. The type of material determines how frequently you will have to perform this operation. To spread the windrow away from the ditch, position the front grader tire on the inside of the windrow. Sideshift the blade and circle so that the toe is positioned outside the windrow, as shown in *Figure 17-22* The heel is positioned to allow the windrow to side cast inside the rear tires. The purpose of the shoulder pickup is to move the windrow away from the foreslope of the ditch.

Figure 17-22 – Shoulder pickup.

The next pass to make is the spreading pass (*Figure 17-23*). Shift the blade and circle back under the grader frame. While the grader straddles the windrow, position the toe of the blade inside the front tire, and position the heel to side cast the material outside the rear tires. Depending on the amount of material, the spreading operation may require several passes. After spreading the material, perform the ditch cut, shoulder pickup, and spreading pass until completing the desired depth of ditch.

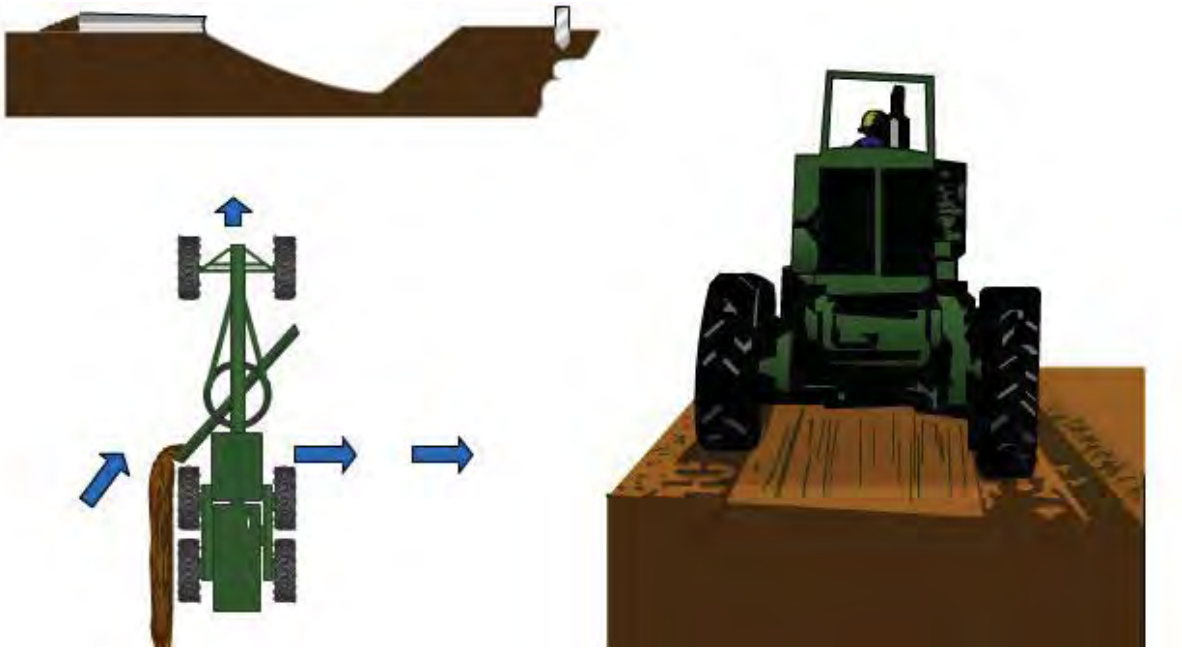


Figure 17-23 – Spreading pass.

When the backslope of the ditch needs to be cut, position the heel of the blade to rest at the very bottom of the foreslope. In this position the material flows inside the right rear tires (*Figure 17-24*). The toe of the blade should be forward toward the right front tire and the tops of the wheels are leaned toward the backslope.

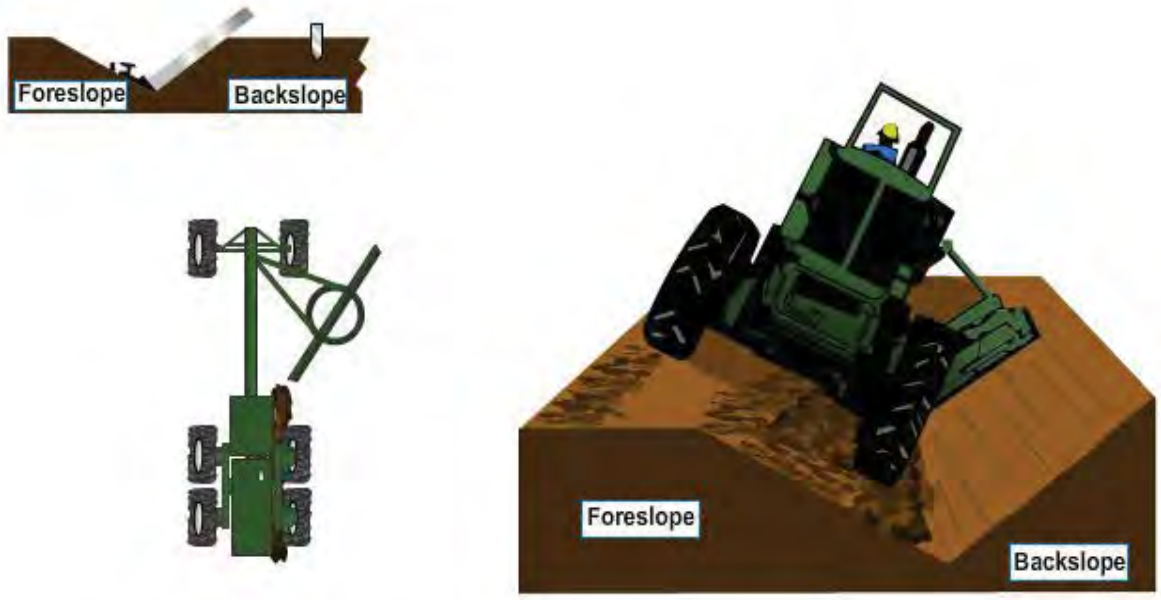


Figure 17-24 – Backslope cut.

If the ditch is to be a V-type, perform a clean-up pass on the foreslope to remove the material from the backslope cut. After cleaning the foreslope, perform a shoulder pickup and a spreading pass to finish the ditching operations.

5.6.0 Flat Bottom Ditch Cutting

If the ditch is to have a flat bottom, proceed as follows:

Starting at the foreslope of the original V-ditch (A), as shown in *Figure 17-25*. Use the same ditch-cutting procedures to cut another V-ditch. After completing the second V-ditch, make a flat cut in the bottom of the ditch. Do this by placing the complete length of the blade in the ditch. The toe is positioned at the base of the backslope (B), and the heel is positioned to side cast the windrow inside the rear tires (C). This operation moves the material to the foreslope of the second V-ditch. To remove the material from the foreslope, perform the procedures used when removing material from a V-ditch.

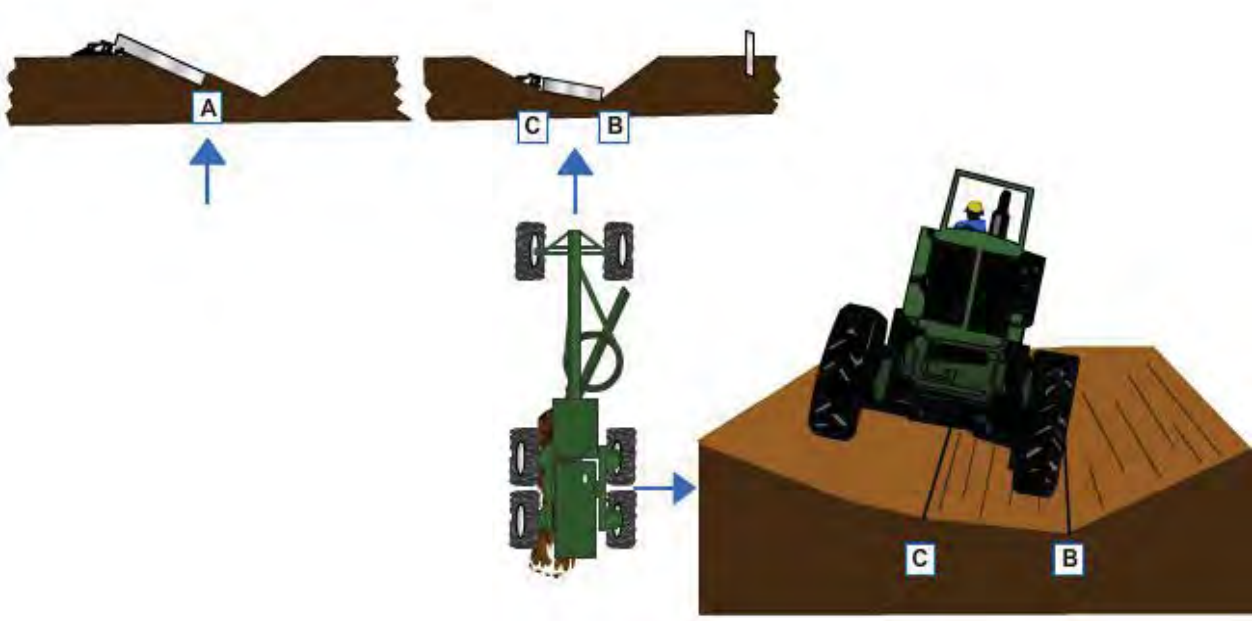


Figure 17-25 – Flat-bottom ditch cut.

5.7.0 Crowning

The crown, or slope, of the road from the centerline toward the shoulders provides drainage to the ditch. For crowning, angle and adjust the blade to conform to the specified angle of the crown. The material is side casted in windrows from the shoulders of the road up toward the centerline.

When the road has a ditch on each side, make the first pass down the length of one shoulder. When the length of the pass warrants, turn around and proceed down the length of the opposite shoulder with the blade adjusted to the same position as the previous pass. When the distance is too short, back up and start on the opposite shoulder with the opposite blade angle adjustment. By repeating overlapping passes made in this manner, you can side cast two windrows from the shoulders to the centerline where they are combined into one. Then spread the center windrow with the blade parallel to the direction of travel. Spread the material that spills out around the blade evenly among the slope of the crown.

NOTE

When grading, the operator cannot obtain a full view of a project site from the operator's seat. For this reason, the operator should stop and climb off the grader periodically to take a look at the work area to determine work progress and areas that need attention.

5.8.0 High Bank Cutting

High bank cuts are used to cut or trim slopes on ditches, deep cuts, and high fills. Position the circle and blade vertically on the side of the grader and angle the blade perpendicular to the line of travel.

NOTE

Read the operator's manual for the type of grader you are operating to receive instructions for setting up the circle and blade for high bank-cutting operations.

When performing high bank cuts, lean the tops of the front wheels toward the bank or slope. Move the grader into position and set the blade on the slope *(Figure 17-26).* When cutting, make light cuts with the toe of the blade.

Figure 17-26 – High bank cut.

The heel of the blade does not require many adjustments. When too much down pressure is placed on the blade, you will lift the side off the grader or cut a gouge in the slope. After the high bank cut is performed, clean the cut material from the base of the slope, using the ditching technique.

5.9.0 Wide Side Reach (Spreading)

A grader may be used to spread piles of loose material. When there is space to work around the pile extend the blade well to the side and angle it to side cast the windrow to the inside of the rear tires. Reduce the pile by using a series of side cuts, as shown in *Figure 17-27*. Piles to be spread by a grader should be spread dumped as much as possible. The load to be spread is limited by the power and traction of the grader.

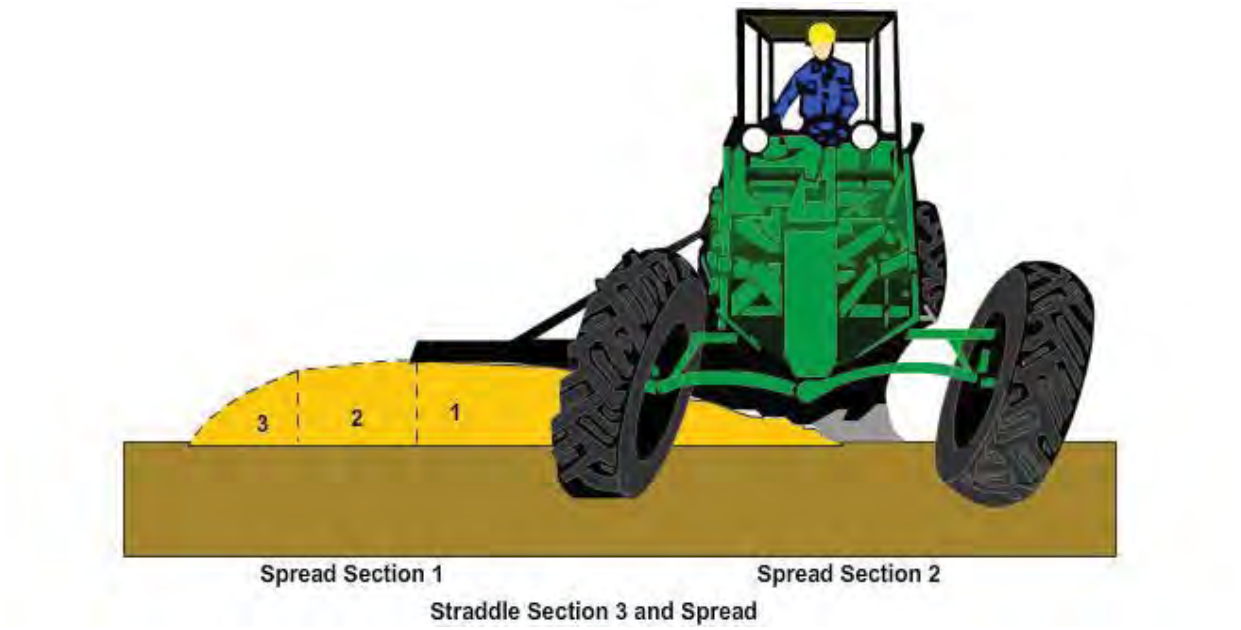


Figure 17-27 – Wide side reach.

When there is not enough room to use the wide side reach and the piles of material are not too high, the front wheels may be driven over the piles. The front axles push the top off the pile, and the blade cuts as much as power permits. Position the blade well below its highest point, so when the grader gets hung up on the piles and loses traction, you can raise the blade to restore the weight to the rear wheels. When traction is lost and the tires spin, unnecessary tire wear increases.

5.10.0 Road Maintenance

The graders ability to blade mix materials used as road surfaces is an important function in road maintenance. When blade mixing, pitch the blade slightly forward and angled at about 30 degrees. This position gives the widest possible spread with maximum mixing action. When mixing, move the windrow from side to side by successive cuts with the blade.

To increase production, use several graders to operate, one behind another, on the same windrow *(Figure 17-28).* When the mixture is wet, mixing should continue until the mixture is dry. After mixing, the material is again side casted into a windrow before spreading. When mixing, more bitumen or cement can be applied to any lean sections. All particles of the completed mix should be coated and uniform in color.

Figure 17-28 – Blade-mixing operations.

Blade-mixing operations are performed as rapidly as possible, consistent with the skill of the operator and the condition of the surface being maintained. However, when the grader is operated too fast, it will tend to bounce and give the surface a washboard appearance that will take additional time and passes to correct. When ***washboarding*** is not corrected, it will create unnecessary wear and tear on traffic using the road or work area.

5.11.0 Snow Removal

Graders can be used for snow removal in the same way as snowplows. Adjust the blade and circle to side cast snow and slush in the same manner as for side casting road materials. When the cutting edges are not removed and replaced with a strip of hard rubber bolted to the moldboard, raise the blade at least 1/2 to 1 inch when removing snow from uneven pavement or a runway surface.

⚠ CAUTION ⚠

Failure to make proper blade adjustments damages the cutting edges, moldboard, or grader and tears up the road or runway surface.

5.12.0 Finish Grading

Finish grading consists of a fine cut or fill to a surface to achieve a desired elevation. This phase of grading is called “blue topping”. Blue topping takes time and patience even for experienced operators.

When performing blue topping operations, make sure that the grader cutting edges are not worn and the tires are the same size, have the correct air pressure, and are pointed in the right direction. The front tire treads should be pointed toward the rear, and the rear tire treads should be pointed toward the front, as shown in *Figure 17-29*.

Adjust the blade pitch fully forward to scrape instead of cut. Before making any cuts on a project, review the project grade hub stakes (blue tops) to note their location and how much cut or fill is needed.

Figure 17-29 – Tire treads on a grader.

NOTE

Compaction of the surface must be done before finish grading can start. When you finish grade, it is better to cut 1/2 to 1 inch than to fill.

A technique used when performing blue topping operations is to divide the project into sections, working one section to final grade at a time. After the first section is at the desired evaluation, you have a reference point from which to start to grade the other sections. As with any earthmoving equipment, it is best to have a level starting point.

When working each section, do not let the material build up into piles that the grader will have to run over. Windrow the material to the end or off the section and have a loader pickup the excess material and move it. If there is room, the excess material can be windrowed off the project for later removal.

When cutting, drag the blade over the top of the hub stake. Final grade is reached when the blade skims the top of the hub stake. Do not cut too deep and knock the hub stake out of the ground. When several passes are required to achieve final grade, the “cut boss” should clean off the top of the stakes so you can see them for your next pass.

5.13.0 Grader Estimates

A part of planning a construction project is estimating how long it will take to complete a construction activity. A work-output formula for preparing preliminary estimates for grader operations is as follows:

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

Where

Total time = Hours required to complete a grader operation

P = Number of passes (P) the grader must take to complete the operations

D = Distance (D) travel in each passes expressed in miles

S = Speed (S) expressed in miles per hour

E = Grader efficiency (E) factor

The most difficult factor to estimate is the speed of the grader. As work progresses on a construction activity, conditions may require increasing or decreasing the speed estimates of the grader. Compute a work output for each operation you perform at a different rate of speed. Add together the total time of each operation for each different speed to compute the total time of the grader operation. *Table 17-1* lists the speeds normally used in various grader operations.

Table 17-1 – Approximate speed ranges used in various grader operations.

OPERATION	SPEED (MPH)	OPERATION	SPEED (MPH)
MAINTENANCE	3 to 10	BANK SLOPING	2
SPREADING	3 to 6	SNOW REMOVAL	10 TO 15*
MIXING	5 to 15		
DITCHING	2 to 3	FINISHING	3 TO 5
*EXCEPTION TO MAXIMUM SPEED PERMISSABLE ON HIGH TYPE RUNWAYS AND HIGHWAYS.			

The grader efficiency (E) factor takes into account the fact that a 60-minute work hour rarely is attained. Efficiency varies, depending upon supervision, operator skill, maintenance requirements, and site conditions. A value of 60 percent is average, computed in decimal form as 0.6. The efficiency factor can be adjusted on each job.

Example problem: Five miles of gravel road is to be leveled and reshaped by using a grader with a 12-foot blade. Six passes are estimated to complete the leveling and reshaping operation. The type of material permits passes 1 and 2 to be performed in second gear at 2.8 mph, passes 3 and 4 in third gear at 3.4 mph, and passes 5 and 6 in fourth gear at 5.4 mph. The efficiency factor for the job is 60 percent.

Calculate how long it will take to complete the job.

$$\textit{Total time for passes } 1 \textit{ and } 2 = \frac{2 \times 5}{2.8 \times 0.6} = \frac{10}{1.68} = 5.90 \textit{ hours}$$

$$\textit{Total time for passes } 3 \textit{ and } 4 = \frac{2 \times 5}{3.4 \times 0.6} = \frac{10}{2.04} = 4.90 \textit{ hours}$$

$$\textit{Total time for passes } 5 \textit{ and } 6 = \frac{2 \times 5}{5.4 \times 0.6} = \frac{10}{3.24} = 3.08 \textit{ hours}$$

Total time of the project = 5.9 + 4.9 + 3.08 = 13.88 *hours*

Always round your answer to the next higher number. In this case, 13.88 is rounded to 14 hours.

Test your Knowledge (Select the Correct Response)

8. What is the first cut performed when cutting a ditch?

   A. Ditch cut
   B. Shoulder pickup
   C. Marking cut
   D. Spreading pass

9. At what direction should an operator position the front wheels of a grader when performing high bank cuts?

   A. Lean the top of the wheels towards the bank
   B. Lean the top of the wheels away from the bank
   C. Steer the wheels towards the bank
   D. Steer the wheels away from the bank

6.0.0 SAFETY

Safety precautions that apply to graders are as follows:

- Keep hands, feet, and clothing away from power-driven parts.
- Wear relatively tight and belted clothing.
- Do NOT wear loose jackets, shirts, sleeves, or other items of clothing because of the danger of catching them in moving parts.
- Before starting the engine, always check the service brakes and the parking brake to ensure they are in proper working condition.
- Do NOT use the steering wheel as a handhold when getting on and off the grader.
- Keep hands, floors, and controls free from water, grease, and mud to ensure nonslip control.
- Never attempt to start or operate the grader except from the operator's station. Always keep the grader in gear when going down steep hills or grades.
- When transporting or driving on a road or highway at night or during the day, use accessory lights and devices for adequate warning to the operators of other vehicles. In this regard, check local government regulations.
- Never drive too close to the edge of a ditch or excavation.
- Do NOT leave the engine running while making adjustments or repairs unless specifically recommended
- Never refuel when the engine is running. Do NOT smoke while filling the fuel tank or servicing the fuel system.
- Never leave the grader unattended with the engine running.
- Do NOT oil, grease, or adjust any part of the grader while it is in motion. Check for faulty wiring or loose connections.
- Keep a firm grip on the steering wheel at all times when speed is increased.
- Do NOT allow anyone near the grader while the driver is in the seat with the engine running.
- Reduce speed before turning or applying brakes. Drive at speeds slow enough to ensure your safety, especially over rough ground.
- Do NOT operate the grader so fast on hillsides or curves that you may tip over.
- When you are operating your grader, be sure your path ahead is clear to avoid collision with other equipment. Watch for overhead wires.

- Never touch wires with any part of the grader.
- Do NOT use the grader as a battering ram.
- Keep the working area as level as possible.
- Never allow anyone to work under a raised blade or other attachment.
- Do NOT leave the blade or other attachment in the raised position when it is not in use. Always lower it to the ground.
- Be sure bystanders are clear of the grader before lowering or moving the blade.
- Park the grader on level ground or across the slope.
- Remove all trash accumulation from the engine and the operator's station daily.
- Wear any required personal protective equipment.

Test your Knowledge (Select the Correct Response)

10. **(True or False)** It is a safe practice to NOT allow anyone to work under a raised blade or other attachment.

    A. True
    B. False

Summary

The grader is one of the most commonly used pieces of construction equipment for final shaping and finishing.

In this chapter you were introduced to the articulated grader and its major components, specifically its moldboard, which can be hydraulically manipulated to lift, lower, shift, rotate, and tilt forward and back. You were also introduced to the rear-mounted ripper and the scarifier, usually mounted behind the front wheels, for breaking up surfaces too hard to cut with the moldboard. You were introduced to the proper use of the grader's leaning front wheels, how to cut V-type and flat bottom ditches as well as eliminate unproductive turns, by traveling in reverse for passes less than 1,000 feet. Lastly, you were introduced to safety practices to which to adhere.

Review Questions (Select the Correct Response)

1. **(True or False)** Crab steering helps compensate for side drift when turning a windrow.

   A. True
   B. False

2. What feature allows the grader to climb rocks, logs, and humps and permits the grader to pass through depressions and ditches one wheel at a time?

   A. Articulated frame
   B. Tandem drive
   C. Crab steering
   D. Ridge frame

3. How would an operator increase the cutting action of the moldboard?

   A. Tilt the moldboard front
   B. Tilt the moldboard back
   C. Angle the moldboard left
   D. Angle the moldboard right

4. What supports and holds the moldboard in position?

   A. Circle knees
   B. Circle arms
   C. V-Knees
   D. V-Arms

5. What component carries the full-horizontal load on the moldboard?

   A. Prime mover
   B. Frame
   C. Circle
   D. Drawbar

6. **(True or False)** Use a scarifier with a complete set of teeth for hard and deep penetration.

   A. True
   B. False

7. What lever is used to rotate the circle 180 degrees to perform reverse blading?

   A. The circle rotation control
   B. The blade circle drive lever
   C. The centershift control
   D. The articulation control

8. How would an operator tilt the top of the blade back?

   A. Push the blade tip control forward
   B. Pull the blade tip control back
   C. Move the blade tip control right
   D. Move the blade tip control left

9. **(True or False)** To move the rear of the grader left, push the articulation control forward.

   A. True
   B. False

10. **(True or False)** The extensive skill required to perform as an effective grader operator is only gained through practice and on-the-job experience.

    A. True
    B. False

11. An operator of a grader counteracts a pulling force to the right on the front of the grader by performing what operation?

    A. Leaning the top of the front wheels to the right
    B. Leaning the top of the front wheels to the left
    C. Turning the steering wheel to the right
    D. Turning the steering wheel to the left

12. **(True or False)** Reverse grading is only for operators who have developed superb skills in grader operations.

    A. True
    B. False

13. When you are grading on a project, it is more efficient to turn the grader around than grade in reverse or back the grader when the distance of the pass exceeds how many feet?

    A. 300
    B. 500
    C. 800
    D. 1,000

14. Which direction is a blade pitch adjusted to achieve a greater cutting action?

    A. Upright
    B. Backward
    C. Slight forward
    D. Fully forward

15. **(True or False)** The proper moisture content supports the binding of material required for compaction.

    A. True
    B. False

16. At what degree angle is the grader blade positioned to perform an efficient ditch cut?

    A. 90°
    B. 75°
    C. 65°
    D. 45°

17. What term is used to describe the operation that spreads material away from the ditching operations and toward the middle of the road?

    A. Ditch cut
    B. Shoulder pickup
    C. Spreading pass
    D. Crowning

18. When you are cutting the backslope of a ditch, the circle and blade is set in a position that ensures the cut material will flow in what direction?

    A. Outside the right rear tires
    B. Outside the right front tire
    C. Inside the right rear tires
    D. Inside the right front tire

19. What term is used to describe the slope of a road from the center line of the road toward the shoulders?

    A. Foreslope
    B. Backslope
    C. Travelway
    D. Crown

20. What limits the spread of a load?

    A. The power and speed of the grader
    B. The speed and traction of the grader
    C. The power and traction of the grader
    D. The traction and size of the grader

21. When performing blade mix operations, the operator should pitch the blade slightly forward and angled at what degree angle?

    A. 10°
    B. 20°
    C. 30°
    D. 40°

22. An operator should raise the grader blade to what height from the surface when performing snow removal operations?

    A. 1/2 to 1 inch
    B. 1 1/2 to 2 inches
    C. 2 1/2 to 3 inches
    D. 3 1/2 to 4 inches

23. What term is used to describe the operation of a fine cut or fill of a surface to achieve a desired elevation?

    A. Finish grading
    B. Elevation achieving
    C. Blue topping
    D. Cat skinning

24. What grader efficiency factor percentage is used for computing grader time estimates?

    A. 90 percent
    B. 80 percent
    C. 70 percent
    D. 60 percent

25. **(True or False)** It is a safe practice to lower the blade or other attachment when the grader is not in use.

    A. True
    B. False

Terms Introduced in this Chapter

Bank	Specifically, a mass of soil rising above a digging or trucking level. Generally, any soil that is to be dug from its natural position.
Scarifying	The action of breaking up hard or compacted material with the use of a scarifier.
Side casting	Piling spoil alongside the ditch from which it is taken.
Washboarding	The name of the process which results in unpaved roads, particularly gravel roads or dirt roads, developing a series of regular bumps with short spacing in the road surface. The result is called a washboard road. Such roads are also known as corrugated roads.

Additional Resources and References

This chapter is intended to present thorough resources for task training. The following reference works are suggested for further study. This is optional material for continued education rather than for task training.

Apprentice Construction Equipment Operator, Volume 1 CDC 131, General Subjects and Contingency Responsibilities, Extension Course Institute, Gunter Air Force Base, Montgomery, AL 1984.

Earthmoving Operations, FM 5-434, Headquarters Department of the Army, Washington, DC, 2000.

Equipment Utilization, U.S. Army Subcourse EN5468, U.S. Army Engineer School, Fort Belvoir, VA, 1988.

Heavy Equipment Operations: Level Three, 2nd ed., National Center for Construction Education and Research, Gainesville, FL and Pearson Education, Inc., Upper Saddle River, NJ, 2006.

Nichols, Herbert L., Jr., *Moving the Earth*, 3rd ed., North Castle Books, Inc., Greenwich, CT, 1985.

Operation and Maintenance Manual: Caterpillar 135H Grader, Caterpillar, 2003.

Operator's Manual: John Deere 670A and 672A Motor Graders, John Deere Davenport Works, OM-T74697, Issue G3.

CSFE Nonresident Training Course – User Update

CSFE makes every effort to keep their manuals up-to-date and free of technical errors. We appreciate your help in this process. If you have an idea for improving this manual, or if you find an error, a typographical mistake, or an inaccuracy in CSFE manuals, please write or email us, using this form or a photocopy. Be sure to include the exact chapter number, topic, detailed description, and correction, if applicable. Your input will be brought to the attention of the Technical Review Committee. Thank you for your assistance.

Write: CSFE N7A
3502 Goodspeed St.
Port Hueneme, CA 93130

FAX: 805/982-5508

E-mail: CSFE_NRTC@navy.mil

Rate____ Course Name_____

Revision Date_____ Chapter Number____ Page Number(s)_____

Description

_____

_____

_____

(Optional) Correction

_____

_____

_____

(Optional) Your Name and Address

_____

_____

_____

Chapter 18

Scrapers

Topics

To hear audio, click on the box. 

Overview

Scrapers are large earthmovers capable of performing a variety of operations, such as cutting, self-loading, hauling, as well as unloading loose material.

This chapter provides the information you need to successfully execute such operations. It describes the types of scrapers used by the Naval Construction Force (NCF) including a description of major components, controls, and cutting edge attachments. In addition, this chapter explains how to perform all phases of the scraper's work cycle as well as how to increase productivity. Last, it lists safety practices.

Objectives

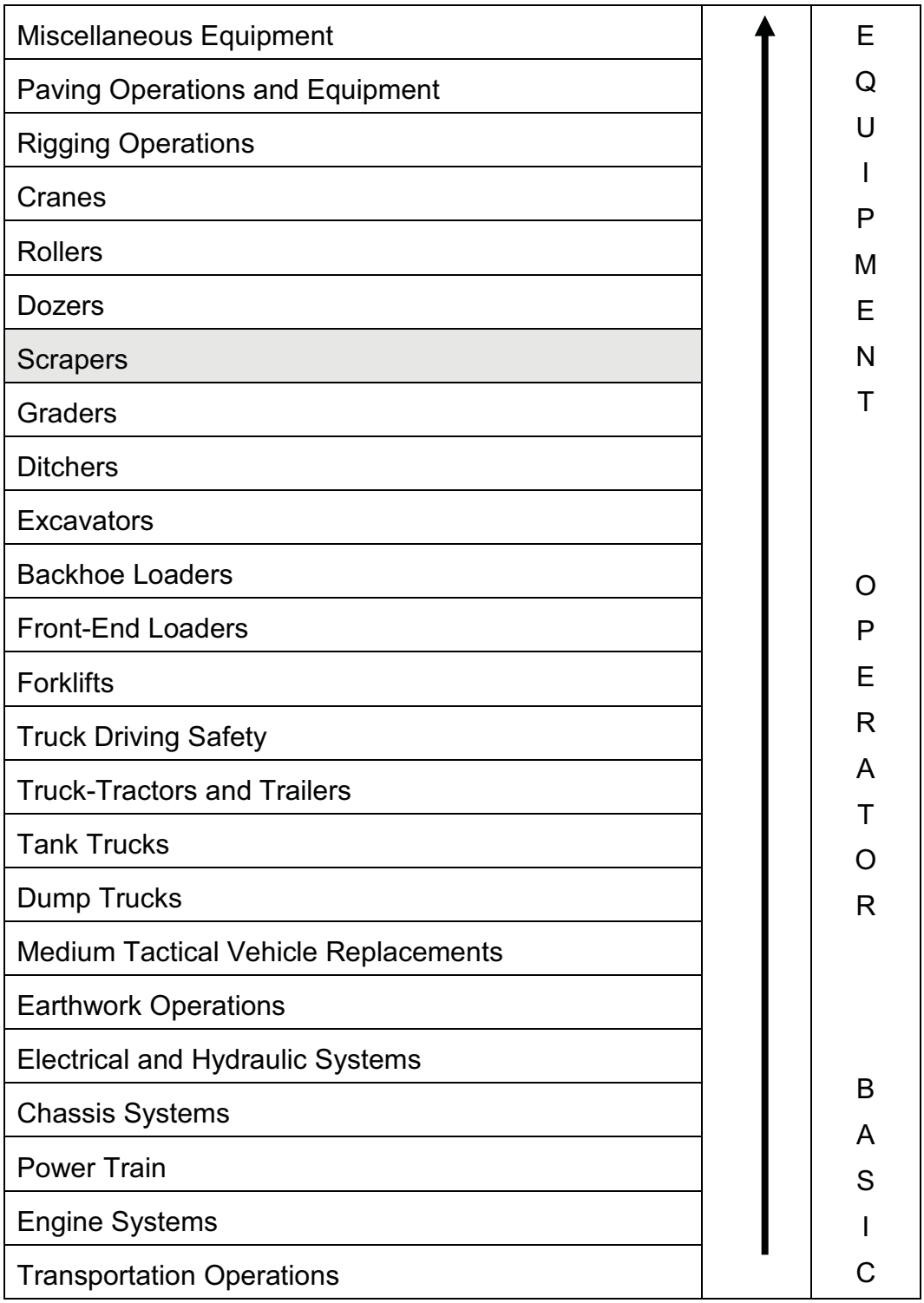
When you have completed this chapter, you will be able to do the following:

1. Understand the use of scrapers.
2. Identify types of scrapers used by NCF.
3. Identify the major components of scrapers.
4. Identify the controls on the scraper.
5. Identify scraper attachments and their use.
6. Understand how to perform scraper operations.
7. Understand scraper safety.

Prerequisites

None

This course map shows all of the chapters in Equipment Operator Basic. The suggested training order begins at the bottom and proceeds up. Skill levels increase as you advance on the course map.



Features of this Manual

This manual has several features which make it easy to use online.

- Figure and table numbers in the text are italicized. The figure or table is either next to or below the text that refers to it.
- The first time a glossary term appears in the text, it is bold and italicized. When your cursor crosses over that word or phrase, a popup box displays with the appropriate definition.
- Audio and video clips are included in the text, with italicized instructions telling you where to click to activate it.
- Review questions that apply to a section are listed under the Test Your Knowledge banner at the end of the section. Select the answer you choose. If the answer is correct, you will be taken to the next section heading. If the answer is incorrect, you will be taken to the area in the chapter where the information is for review. When you have completed your review, select anywhere in that area to return to the review question. Try to answer the question again.
- Review questions are included at the end of this chapter. Select the answer you choose. If the answer is correct, you will be taken to the next question. If the answer is incorrect, you will be taken to the area in the chapter where the information is for review. When you have completed your review, select anywhere in that area to return to the review question. Try to answer the question again.

1.0.0 SCRAPERS

Equipped with a large bowl with a cutting edge attached to the bottom, scrapers can cut, self-load, haul, and spread a great amount of material. They are most efficient when operated in light and medium materials that are nearly free of roots, stumps, and boulders. Heavy or consolidated materials require ripper-equipped dozers to rip open the surface and assist loading operations by pushing the scraper through the cut to achieve maximum loading. A dozer pushing the scraper is referred to as a push cat.

1.1.0 Types of Scrapers Used By Naval Construction Force

The NCF uses three types of scrapers: the single engine, twin engine, and paddle wheel scraper. The sizes of these scrapers determine the depth of the cut as well as the amount of material they can haul.

1.1.1 Single-Engine Scraper

The single-engine scraper, like the one shown in *Figure 18-1*, is essentially a tractor with one engine coupled to a scraper unit. During loading operations, its single-engine does not provide sufficient power or traction to completely load the bowl; therefore, the assistance of a push cat is often required, as shown in *Figure 18-2*.

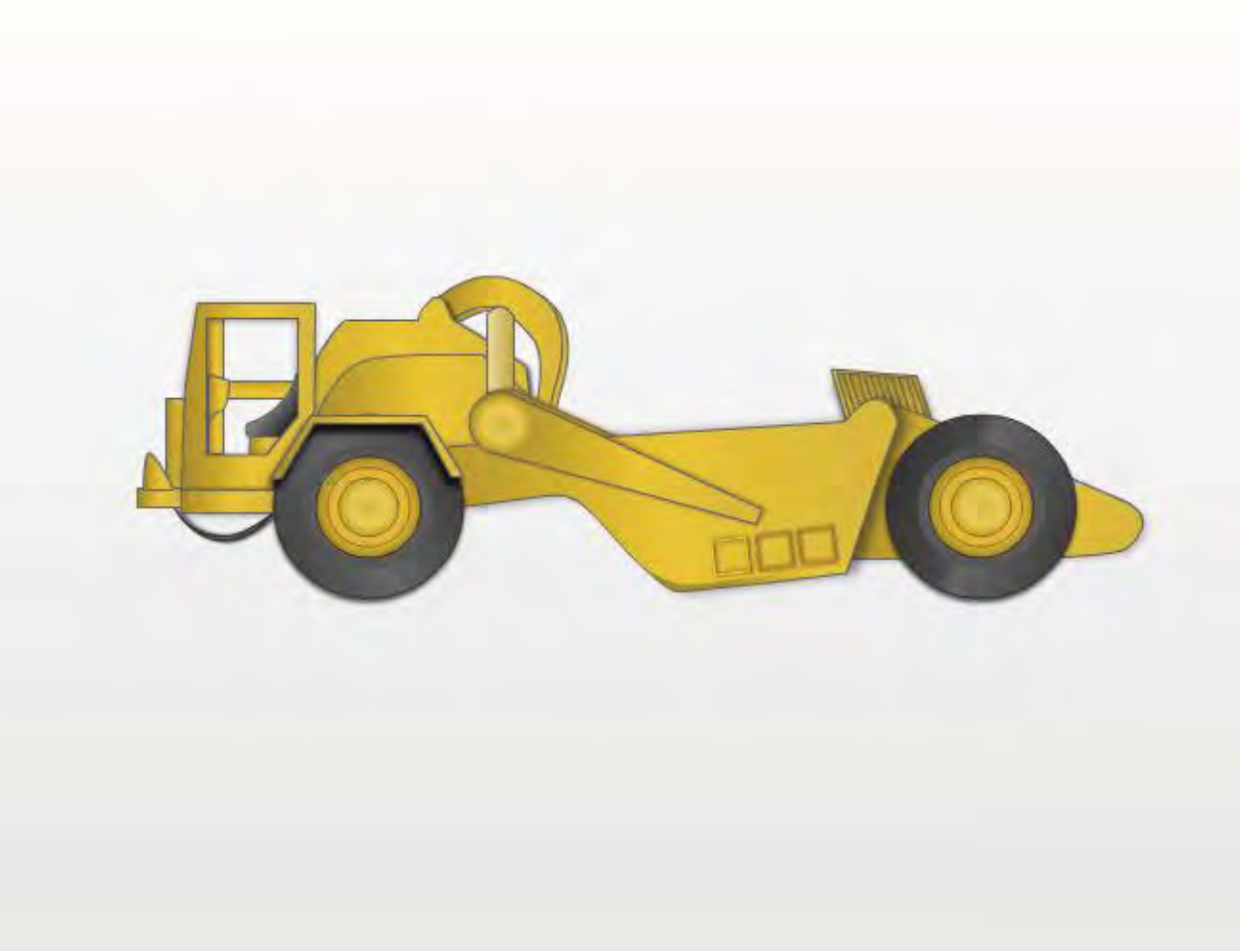


Figure 18-1 – Single-engine scraper.

Figure 18-2 – Push cat pushing scraper.

1.1.2 Twin-Engine Scraper

The twin-engine scraper is also referred to as the push-pull scraper because it has two engines. The engine in the tractor unit pulls the machine, while the other engine at the rear of the scraper unit pushes the machine, as shown in *Figure 18-3*. Under certain loading conditions, two twin-engine scrapers may need to work in tandem. The scrapers are joined together by a rear-mounted hook and a front triangular bail, as shown in *Figure 18-4.*

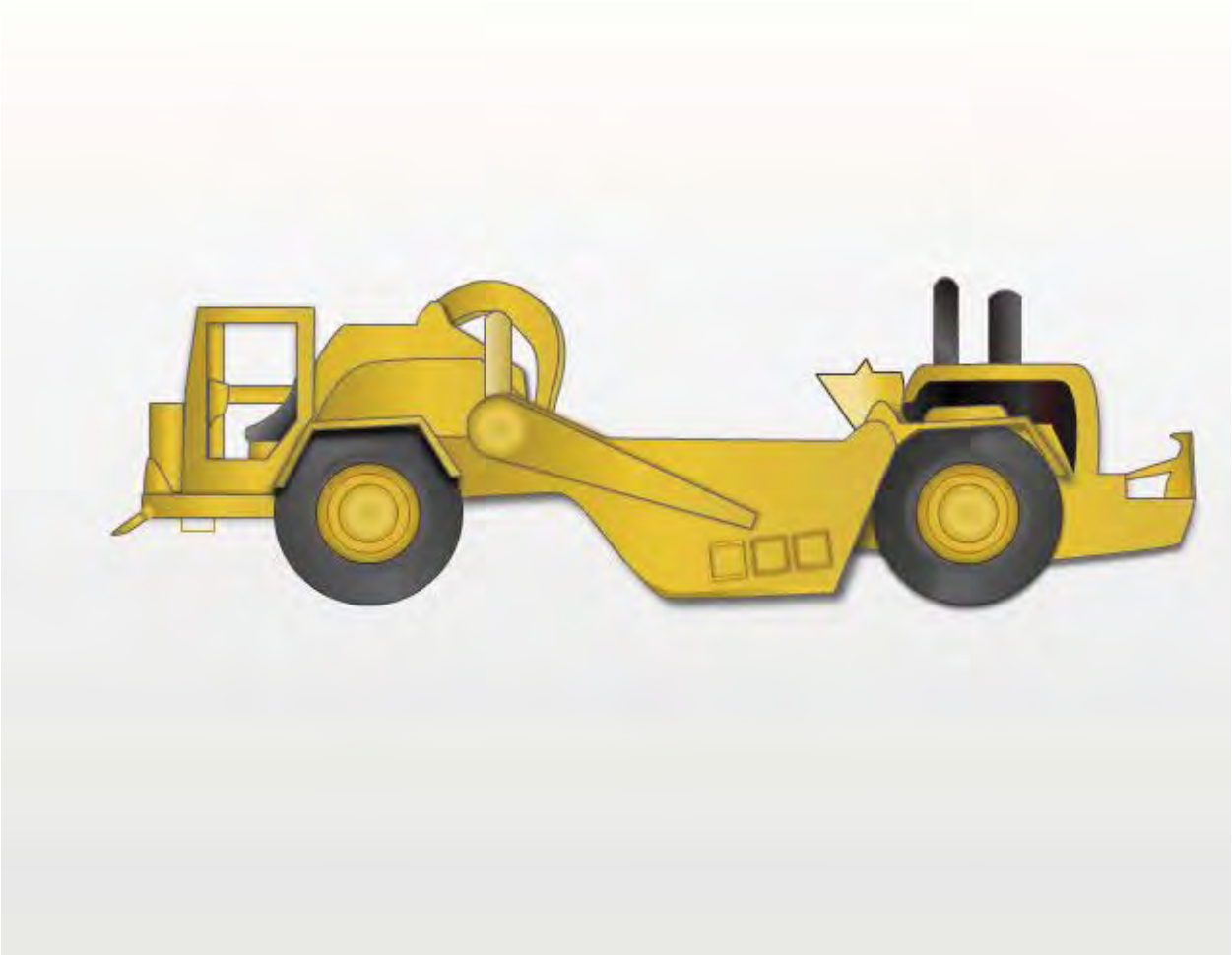


Figure 18-3 – Twin-engine scraper.

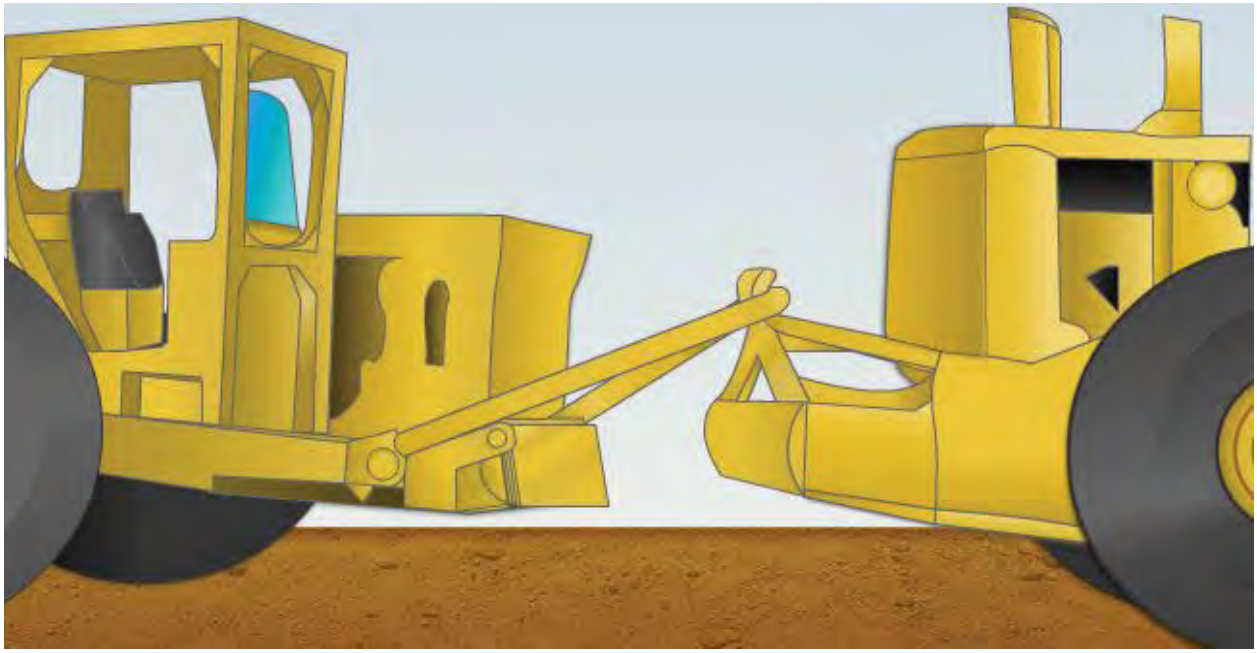


Figure 18-4 – Hook and bail.

1.1.3 Paddle Wheel Scraper

Another type of scraper used in the NCF is the paddle wheel scraper, shown in *Figure 18-5*, also called the elevating scraper. This type of scraper is ideal for small- to medium-size earthmoving jobs, and on most projects does not require a push cat. After the material has been cut by the cutting edge, the material is not forced to the top as on other scrapers; instead, the scraper loads its bowl from the top by means of a paddle wheel elevator. The paddle also aids in breaking up the material, creating a more consistent load.

The bowl can be unloaded by placing the paddle wheel in reverse. This gives the operator more control of the desired depth of fill. For increased productivity, the operator is also able to control the speed of the elevator to match the material condition.

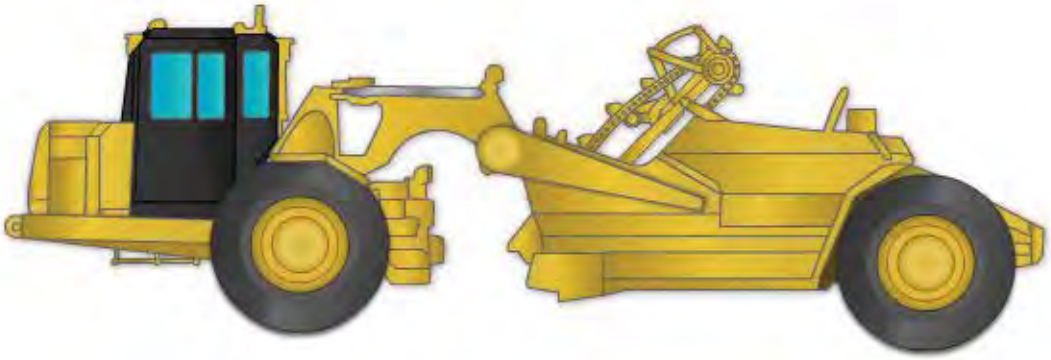


Figure 18-5 – Paddle wheel scraper.

Test your Knowledge (Select the Correct Response)

1. **(True or False)** Scrapers are most efficient when operated in medium to heavy materials that are nearly free of roots, stumps, and boulders.

   A. True
   B. False

2. Which of the following scrapers has a rear-mounted hook and a front bail?

A. Single-engine scraper
B. Twin-engine scraper
C. Paddle wheel scraper
D. Push cat scraper

2.0.0 MAJOR COMPONENTS

Depending on make, model, and configuration, major components on scrapers may vary; therefore, you are responsible for reading the operator's manual for specific information. For a general understanding, the major components of a Caterpillar 621B single-engine scraper are shown in *Figure 18-6.*

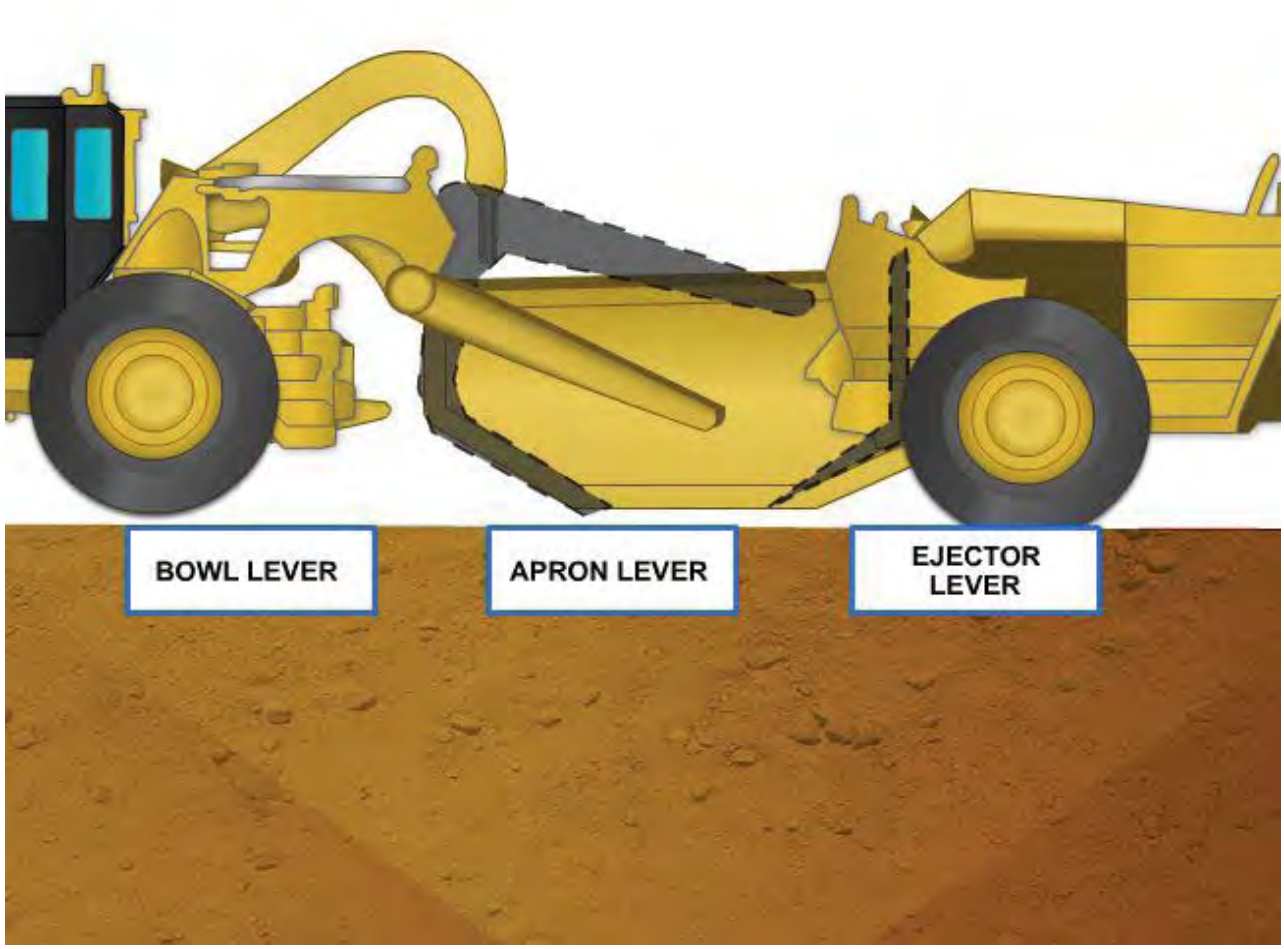


Figure 18-6 – Major components.

2.1.0 Tractor Unit

The tractor unit contains the engine, the drive train and wheels, the hydraulic pumps, and the operator's cab. The tractor is connected to the scraper by a vertical kingpin swivel connection, usually in two parts with upper and lower pins. When steering, this connection permits turns of 85 to 90 degrees to each side of the center line of the scraper. There is also a longitudinal horizontal hinge that permits the two units to move independently from side to side, as shown in *Figure 18-7*.

Figure 18-7 – Articulation.

2.2.0 Gooseneck

The gooseneck couples the tractor and scraper unit. By arching up, it provides space for the tractor wheels to move under it. The gooseneck then widens into a very massive crossbeam becoming a pair of lift arms, also known as bowl stiffeners, which extend back to the ***trunnion*** fastenings on the sides of the scraper bowl.

The gooseneck supports the steering cylinders as well as the cylinders that raise and lower the bowl and apron.

2.3.0 Scraper Unit

The scraper unit has three basic operating parts: the bowl, apron, and ejector.

2.3.1 Bowl

The bowl is a box with rigid sides. Bolted to its bottom is a cutting edge consisting of three blades made of wear-resistant steel. The bottom front sides of the bowl usually have bolted-on wear plates called side cutters. The side cutters normally receive less wear than the cutting edge.

By use of a lever inside the operator's cab, the bowl can be hydraulically lowered or raised. As the scraper travels forward, the bowl is lowered to cut into the material. The cut material is then forced into the bowl. Once the bowl is completely loaded, it is then raised. The material is hauled to a designated location where it is unloaded or spread.

Conveniently, the top of the bowl is open so that spread material can be loaded by crane clam shell, conveyor, or front-end loader.

2.3.2 Apron

The apron forms the forward section and a variable amount of the bottom of the bowl assembly. The apron is also hydraulically raised or lowered by use of a lever inside the operator's cab. When lowered (closed), it rests at the cutting edge to prevent spillage. When raised, it leaves the whole front of the bowl open to accept material.

2.3.3 Ejector

The ejector is the rear wall of the bowl. The most common ejector is hydraulically controlled to move forward horizontally to force the load out of the bowl. It is supported by rollers riding on the floor and on tracks welded to the sides of the bowl.

2.4.0 Push Block

The push block extends past the scraper's rear tires. It is used during loading operations by the push cat while providing extra power.

Test your Knowledge (Select the Correct Response)

3. **(True or False)** The gooseneck supports the cylinders for steering and for operating the bowl and apron.

   A. True
   B. False

4. The bottom front sides of a scraper bowl usually have bolt-on wear plates that are known by what term?

   A. End bits
   B. Wear bits
   C. Side cutters
   D. End cutters

3.0.0 CONTROLS

The bowl, apron, and ejector are controlled by either levers or a joystick. Such controls are located along the cab's right side window. This arrangement allows you to look over your right shoulder to view the bowl while operating it, as shown in *Figure 18-8.*

Figure 18-8 – Operator viewing bowl.

As shown in *Figure 18-9*, the Caterpillar 621B has three levers. Each lever has four positions: completely and slightly right (away from the operator), center, and left (towards the operator). When these levers are released from either the right or left positions, they will return to the center position, whereupon the operation will stop.

Figure 18-9 – Controls.

3.1.0 Bowl Lever

The bowl lever raises and lowers the bowl.

- To quickly drop the bowl, completely move the bowl lever to the right, away from you.
- To slowly lower the bowl, slightly move the lever right.
- To raise the bowl, move the lever left, towards you.

3.2.0 Apron Lever

The apron control lever raises (opens) and lowers (closes) the apron.

- To allow the apron to seek its own level (float), completely move the apron lever to the right, away from you.
- To lower the apron, slightly move the lever right.
- To raise the apron, move the lever left, towards you.

3.3.0 Ejector Lever

The ejector lever moves the ejector forward and back.

- To release the ejector, completely move the ejector lever to the right, away from you.
- To move the ejector back, slightly move the lever right.
- To move the ejector forward, move the lever left, towards you.

NOTE

For maximum operating efficiency, operate the engine at maximum rated speed and the control levers at their extreme operating position.

Figure 18-10 allows you to operate these three levers.

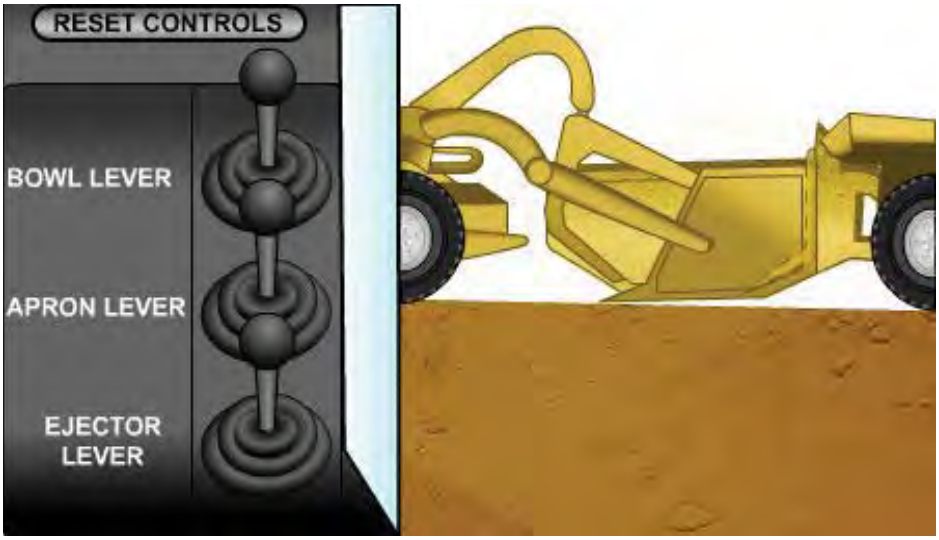


Figure 18-10 – Operating scraper controls.

Test your Knowledge (Select the Correct Response)

5. **(True or False)** On the Caterpillar 621B, the bowl, apron, and ejector are controlled by a joystick.

   A. True
   B. False

6. On the Caterpillar 621B, how would an operator quickly lower the bowl?

   A. Move the bowl lever completely to the right.
   B. Move the bowl lever slightly to the right.
   C. Move the joystick completely to the right.
   D. Move the joystick slightly to the right.

4.0.0 ATTACHMENTS

Unlike other pieces of equipment, there are very few attachments used with or on scrapers; however, there are three commonly used cutting edges that serve various purposes. They are the straight, curved and three-piece cutting edges, shown in *Figure 18-11*. These cutting edges are available in various thicknesses. Thinner edges provide

greater penetration, but have less wear material and impact resistance compared to thicker edges.

4.1.0 Straight Cutting Edge

The straight cutting edge is the most efficient for smooth finish grading.

4.2.0 Curved Cutting Edge

The curved cutting edge penetrates more than the straight edge.

4.3.0 Three-Piece Cutting Edge

The three-piece cutting edge has a center blade positioned ahead of the other two blades for deeper penetration. This center blade is referred to as the stinger.

NOTE

Replace cutting edges that are worn or damaged to prevent wear of the scraper bowl.

Test your Knowledge

7. On a three-piece cutting edge, what term is used to identify the center blade?

   A. Stinger
   B. Point cutter
   C. Scraper
   D. Intermediate bit

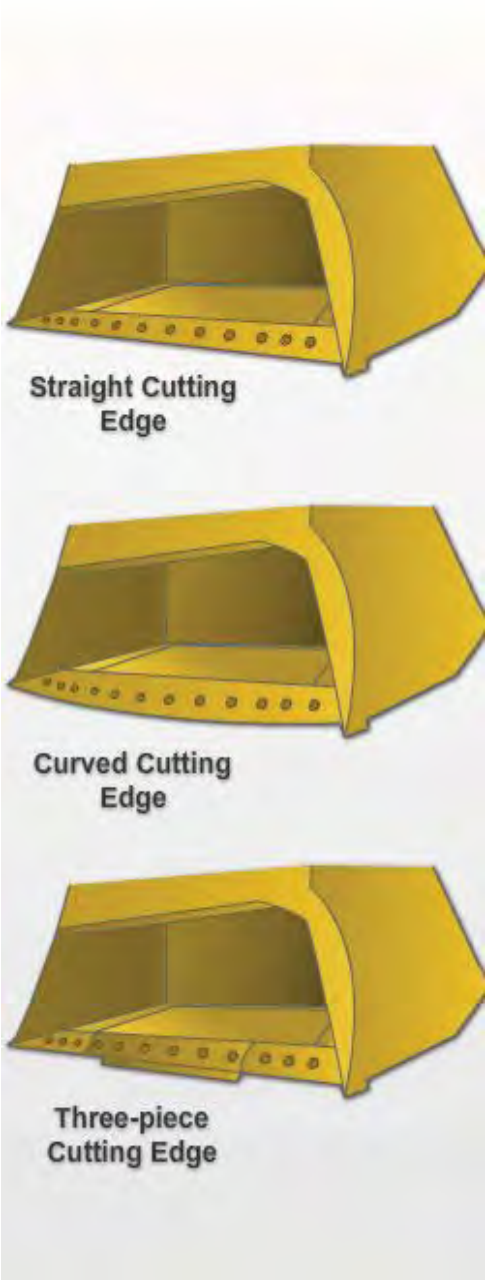


Figure 18-11 – Cutting edges.

5.0.0 OPERATIONS

The greatest engine power is available when the engine is running at top governed speed. The proper transmission gear ratios must also be engaged to obtain maximum engine power output. When the transmission is placed in too high a gear ratio for full engine power, the result is a stall condition in the transmission converter. Stalling the converter prevents the engine from operating at maximum efficiency and results in rapid overheating and premature wear of the converter or transmission.

Downshift the transmission correctly while the scraper is in motion to prevent damage to the power train. Improper downshifting overspeeds the transmission and engine, and usually results in premature wear and unnecessary transmission breakdowns.

When moving the scraper from a full stop, always start with the transmission in low gear, depressing the throttle for the degree of acceleration required. A wide open throttle provides the fastest acceleration under full-load conditions.

When running downgrade, avoid overspeeding the engine by keeping the scraper speed at or below the maximum speed for the transmission range engaged. As a

general rule, downhill scraper speed should not exceed 5 mph more than that attained on level ground in the transmission ratio engaged.

When the selected transmission ratio is too high, slow the scraper with the service brakes until you can properly downshift the transmission to the required range for the grade.

If necessary, you can slow the downhill speed by lowering the scraper bowl until the cutting edge drags enough to slow the scraper to the required speed to permit proper downshifting or stopping.

Do not fan the brakes by repeated depressing and releasing. This practice can reduce air pressure below the point required for proper braking. The air pressure system should indicate 105 to 125 psi on the air pressure gauge for effective braking. When the gauge indicates a pressure drop below 105 psi for a long time, shut down the scraper until the trouble is corrected.

5.1.0 Work Cycle

The scraper's work cycle has four phases of operation: loading, hauling, spreading or unloading, and returning to the cut.

5.1.1 Loading

When loading, enter the cut with the ejector positioned at the rear of the bowl, open the apron enough to allow material to enter the bowl (normally 4 to 8 inches above the leading edge of the bowl), and then lower the bowl to cut a depth of 1 to 1 1/2 inches. The gear that the transmission is engaged in depends on the nature of the material being cut. For light, loose material, a relatively high gear can be used. For heavy, compacted material, a low gear is used; however, to obtain a full load, use a lower gear, even in loose material. As the scraper proceeds through the cut, the material is loosened by the scraper cutting edges and forced into the bowl by the forward motion of the scraper, as shown in *Figure 18-12*.

Figure 18-12 – Entering the cut.

NOTE

Avoid spinning the scraper tires during cutting operations. Spinning the tires is nonproductive and causes expensive premature wear to the tires, differential, and transmission.

The material entering the bowl boils back against the ejector and forward against the apron, as shown in *Figure 18-13*. When the bowl is filled to capacity, commonly known as “heaped,” close the apron, and at the same time, raise the bowl 1 or 2 inches above the ground, as shown in *Figure 18-14*. On scrapers equipped with diverter valves in the apron hoist system, the bowl automatically starts rising while the apron control lever is held in the lower position. After the scraper is fully loaded and the bowl is raised, continue to travel out of the cut with the scraper bowl at a height that spreads out the material that piles in front of the cutting edges.

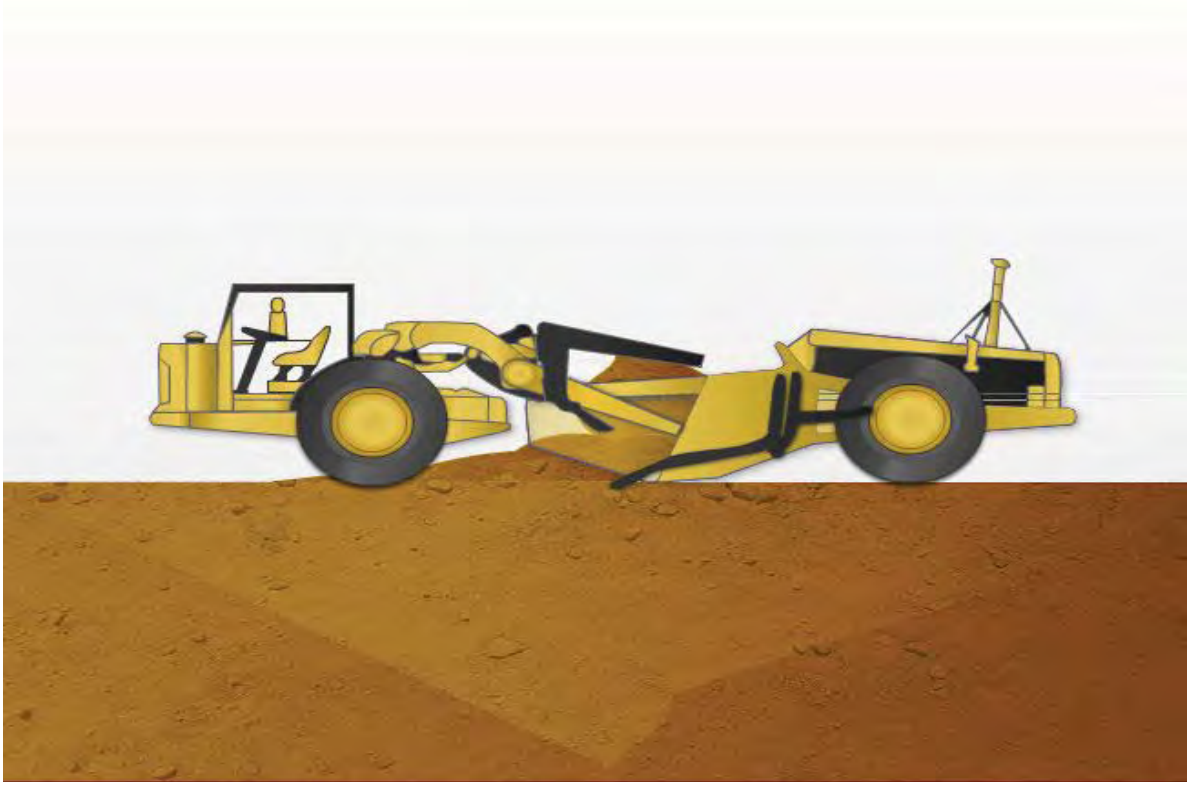


Figure 18-13 – Loading the bowl.

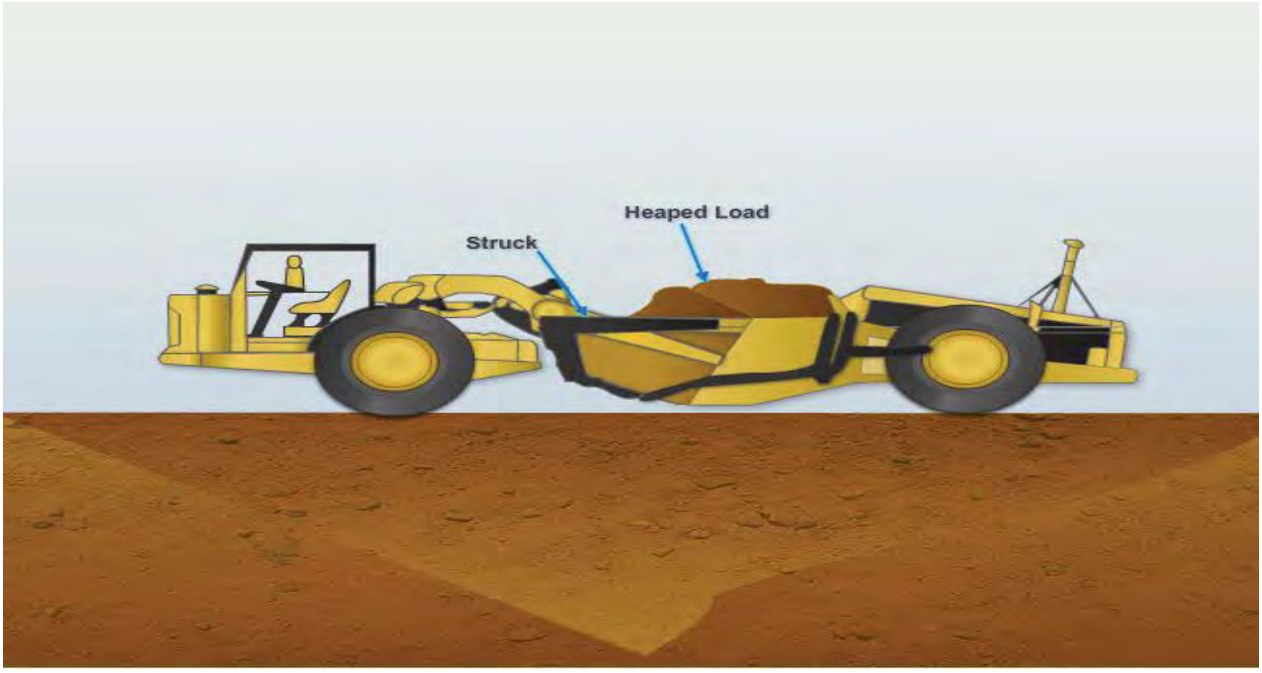


Figure 18-14 – Loaded bowl.

5.1.2 Hauling

After the scraper is fully loaded and has reached the haul road, raise the bowl to travel height and proceed to the fill or dump area in the highest gear range practicable. The bowl travel height should be no higher than needed to clear any obstacles on the haul road. A low bowl height allows better control of the scraper by keeping the center of gravity low and preventing the loss of time needed to lower the bowl as the scraper approaches the fill area. The best bowl height is the height at which the bowl must be when the load is spread.

When hauling down steep grades, lower the bowl until the cutting edge drags to slow the scraper down. When traveling over a slippery haul road, keep the bowl as low as possible to allow for a fast emergency stop by dropping the bowl.

When traveling over haul roads, avoid holes and large obstacles that may damage the scraper tires. When making sharp turns, allow enough clearance for the length and width of the scraper to keep the scraper wheels on the road.

5.1.3 Spreading or Unloading

When approaching the fill area, lower or raise the scraper bowl to the depth of fill desired. Also adjust the speed of the scraper for this depth, such as a high speed for a thin spread or a slower speed for a deep spread.

To start spreading, raise the apron by engaging the apron control lever to allow the material to fall out of the bowl. The size of the apron opening depends mainly upon the depth of the spread and type of material being spread, for example, a thin layer of free-flowing sand needs a fairly small apron opening and a high travel speed, while a thin spread of wet clay will need a larger opening and a slower travel speed.

After the apron opening has been adjusted and the dirt flowing through the opening lessens, engage the ejector lever to finish unloading the scraper bowl. When the scraper is empty, engage the ejector lever to return the ejector to the rear of the bowl and lower the apron.

Unloading techniques are as follows:

- Keep the scraper moving while unloading. Stopping when unloading on soft fill costs production time by needless shifting and the possible miring down of the scraper.
- Always make an even spread, so the next trip will not be rough.
- If possible, when traveling out of a fill, pass back over the area you have just filled to compact it with the large scraper tires.

5.1.4 Returning to the Cut

After unloading the scraper and reaching the haul road, return to the cut as soon as possible. When returning to the cut, carry the scraper bowl high enough to avoid any haul road obstacles, yet low enough for safe handling of the scraper. Carrying the bowl low allows for quick lowering of the bowl to stop the scraper in the event of an emergency. Allow plenty of room for the rear wheel of the scraper to avoid obstacles when making tight turns, and maintain a safe speed for the condition of the haul road.

5.2.0 Using a Push Cat

During loading operations, when a push cat is used to supply extra power to the scraper, it should be positioned about 45 degrees off the lane to be cut. The scraper should start loading before the push cat makes a smooth contact with the rear push block.

CAUTION

The push cat operator should be extremely cautious to avoid hitting the rear scraper tires with the dozer blade.

The push cat operator must be sure to center the reinforced section of the dozer blade on the scraper rear push block. Additionally, the push cat operator must be alert to turns made by the scraper that might cause the push cat to apply unequal pushing force. This could result in the dozer blade contacting the scraper rear tires or causing the scraper to jackknife. The push cat should continue pushing after the scraper has a full load to give the scraper a boost in leaving the cut.

5.3.0 Working Difficult Materials

Special operating techniques are required when you perform scraper operations in difficult materials, such as wet or sticky material, loose sand or gravel, and large objects.

5.3.1 Wet and Sticky Materials

When unloading wet and sticky material, do not try to spread the material too thin. Always keep the bowl high enough to allow the material to flow back under the scraper. Open the apron wide enough to allow an easy flow out of the bowl, Bring the ejector forward with short, snappy movements of the ejector control lever to shake the material loose from it. Allow a little time between each ejector movement to avoid compacting the material between the apron and ejector. In some cases, shifting the ejector between forward and reverse gives the material that has been brought forward a chance to fall out of the apron opening.

NOTE

When the material is spread too thin or the bowl is too low, the material will pack against the scraper cutting edge inside the bowl and will not eject.

5.3.2 Loose Sand and Gravel

Sand is a free-flowing material that tends to float ahead of the scraper cutting edges when being loaded. To obtain a heap load and to avoid being bogged down by the sand, use the technique called pump loading.

To pump load, enter the cut with the apron open about 3 feet and the scraper cutting edges lowered into the sand. Continue through the cut until the engine(s) start(s) to lug down. Then lower the apron into the sand that has piled up in front of the scraper cutting edges, and raise the bowl 2 or 3 inches at a time. Do not completely close the apron or drop the bowl so deep that the engine stalls. This loading technique will ordinarily allow the scraper to get a full load.

When spreading sand, always spread it as thin as possible, and keep the scraper moving in the fill. A thin spread allows better compaction and makes it easier to travel over the fill.

To obtain a full load when loading gravel, you may have to pump load as performed with sand. The apron may be hard to close due to stones getting caught between the apron and cutting edges. A technique used to avoid the stones is to backup a few inches with the cutting edge still in the ground while closing the apron. This should force the stones out and allow the apron to close all the way.

5.3.3 Large Objects

Scrapers are not designed to dig or transport large objects; however, they may be used for this purpose when more suitable equipment is not available.

Approach the object with the apron and scraper bowl fully raised. When the object is too large to clear underneath the tractor, bring the tractor past the object until the drive wheels are a few inches beyond it. Pivot the tractor sharply towards the object to allow the tractor to bypass the object, and bring the cutting edge into position for loading, as shown in *Figure 18-15*.

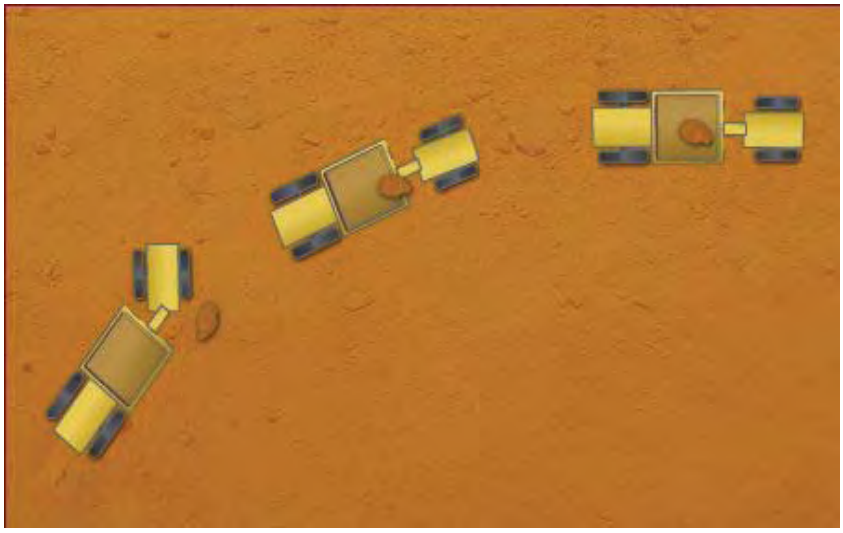


Figure 18-15 – Maneuvering to load a large object.

When the tractor reaches its sharpest angle of the turn, bring the scraper cutting edges within a few inches of the object. Lower the bowl, apply downward pressure, and move forward. When the cutting edge hooks underneath the object, lift the bowl while inching forward. When the object slips off the cutting edge, back up and try again. You may have to approach the object from a different direction to get a grip to load the object.

To shove the object around, keep the ejector in the full forward position. To pick up and carry the object, place the ejector in the normal full back position. To close the apron completely after the object has been loaded, scrape up a little dirt that will push the object back farther into the bowl.

To unload the object, shift the ejector from forward to reverse several times to move the object around so it will fall out. After unloading the object, turn the tractor sharply so the scraper clears the unloaded object.

NOTE

Use extreme care when handling large objects. Oversize objects, such as large rocks, can cause damage by denting, bending, or straining parts. Damage may also be done by accidental collision with large rocks during ordinary digging.

5.4.0 Production Techniques

Scraper production techniques are used to achieve the most amount of work with the scrapers assigned. These techniques are as follows:

5.4.1 Downhill Loading

Downhill loading uses the force of gravity on the scraper to get larger loads in less time. The added force of gravity is 20 pounds per gross ton of weight per 1 percent of downhill grade. The downhill pull adds more material per load, and the added material weight increases the total gravitational pull.

5.4.2 Straddle Loading

Straddle loading gains time on every third trip because the center strip loads with less resistance than a full cut. After the first scraper has made a cut, the second scraper should make a parallel cut while leaving a 4- to 5-foot-wide island between the two cuts, as shown in *Figure 18-16.* The third scraper can straddle this island of material to achieve a fast, less resistant load.

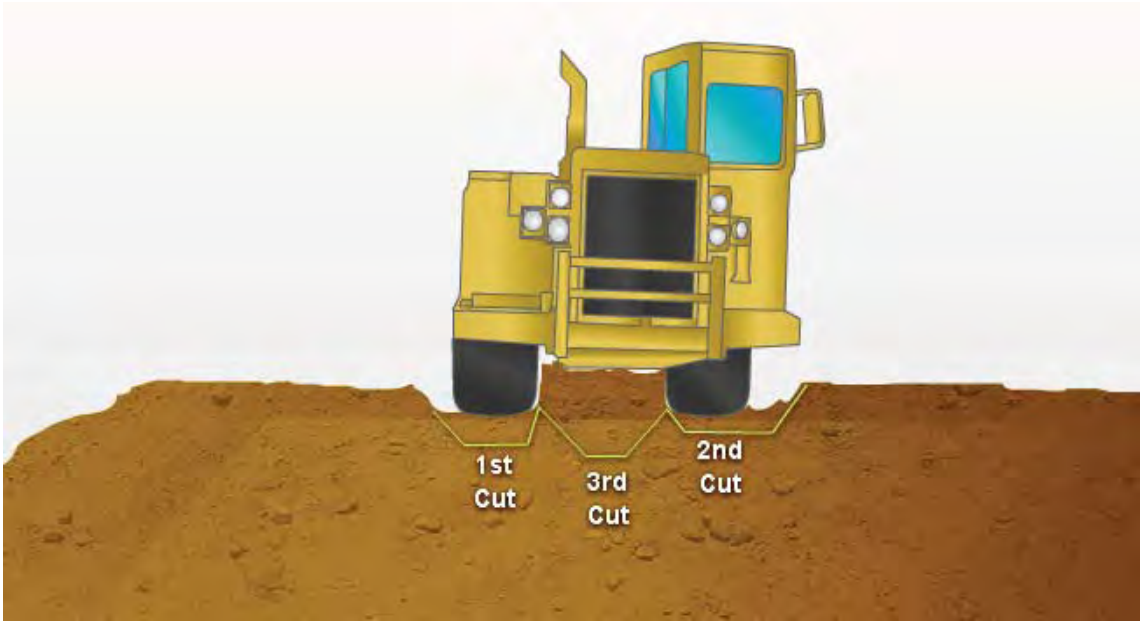


Figure 18-16 – Straddle loading.

5.4.3 Back-Track Loading

Back-track loading, shown in *Figure 18-17,* is used only when the cut is fairly short and loading in both directions is impractical. A great deal of time is spent backtracking and maneuvering the push cat for the next load; therefore, if the cut is wide enough, try other techniques.

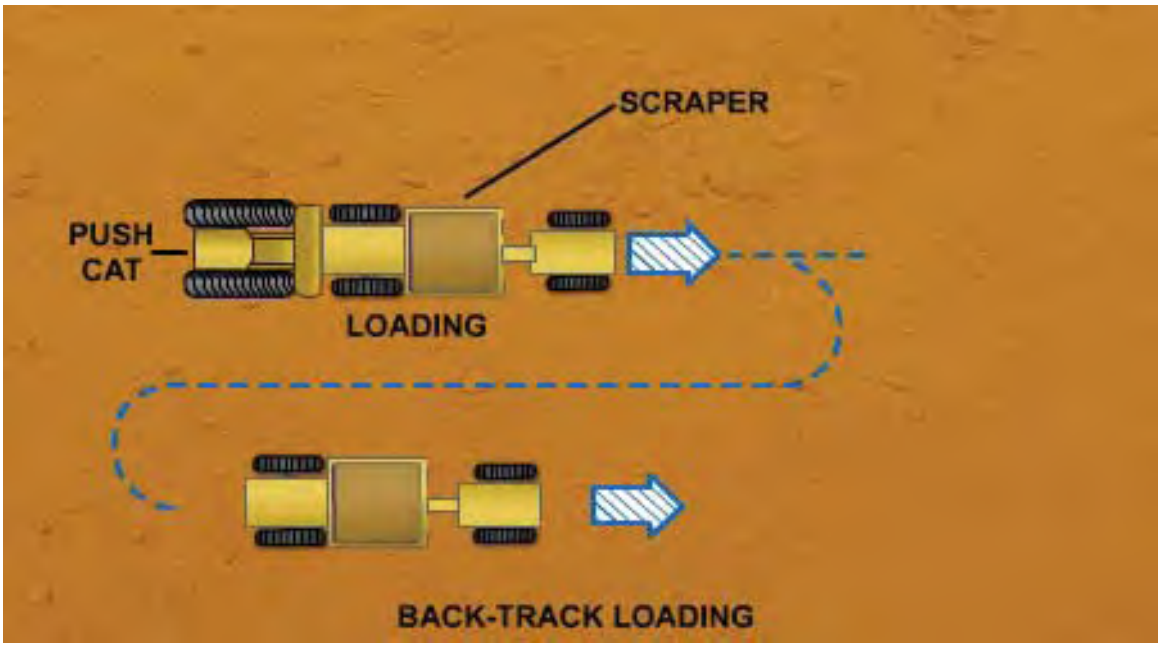


Figure 18-17 – Back-track loading.

5.4.4 Shuttle Loading

Shuttle loading is used for short cuts where it is possible to load in both directions, as shown in *Figure 18-18*. The push cat pushes one scraper in one direction, then turns to push a second scraper in the opposite direction.

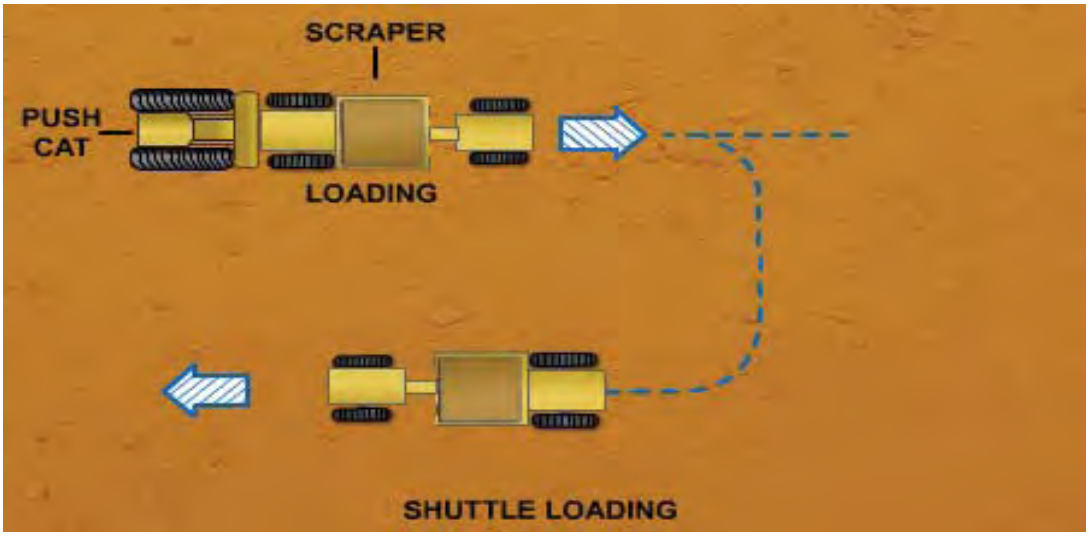


Figure 18-18 – Shuttle loading.

5.4.5 Chain Loading

Chain loading is used when the cut is fairly long, making it possible for the push cat to pickup two or more scraper loads without back tracking, as shown in *Figure 18-19*. The push cat push loads one scraper, then moves in behind another scraper that is moving parallel to the first scraper.

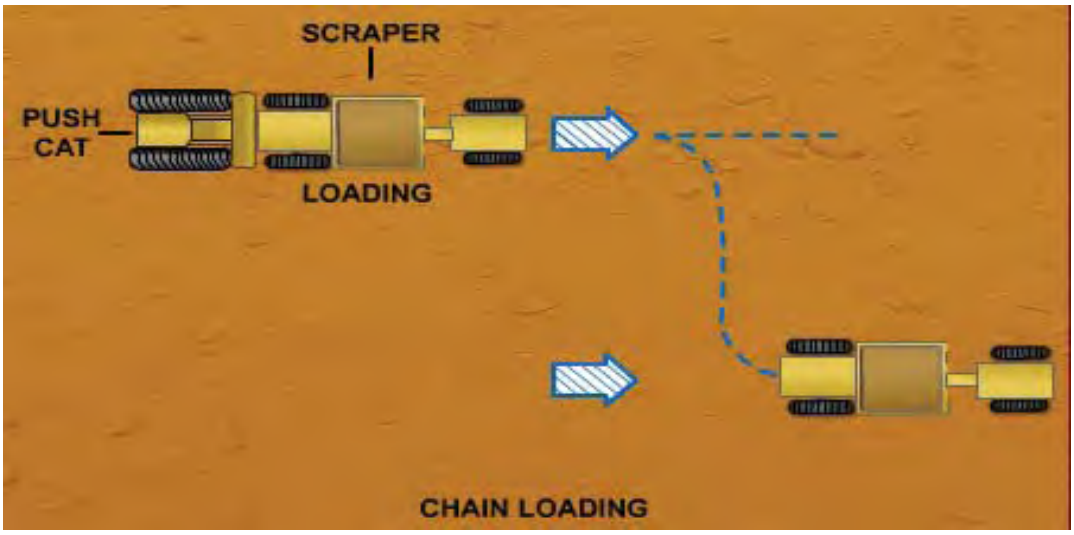


Figure 18-19 – Chain loading.

5.4.6 Optimum Loading

Optimum loading is an operation used when loading time and maximum output are critical. With the assistance of push cats, scrapers should be loaded within 1 minute per 100 feet. You may use more time and distance to obtain more material when the haul is long enough and the added material is great enough to offset hauling fewer loads.

While scrapers are waiting for push cat assistance, spend time cutting without attaining a heaped load. While push cats wait for scrapers, they should be dressing the cut. In some cases, using a dozer to dress the cut full time will increase production. At the end of a workday, take time to shape the cut for good drainage.

NOTE

Maintaining adequate drainage throughout a cut and fill operation reduces compulsory downtime caused by bad weather.

The rule of thumb used for computing the number of push cats required for a scraper operation is to divide the scraper cycle time by the push cat cycle time. When computing cycle time for a scraper, take the total time of loading, hauling, unloading, and return; for instance, a 5-minute scraper cycle time divided by a l-minute push cat cycle time calls for five scrapers per push cat.

5.4.7 Turns

Take turns within the shortest radius possible and at the highest safe speed. If possible, use the sequence shown in *Figure 18-20* to eliminate unnecessary turns when performing cut and spread operations.

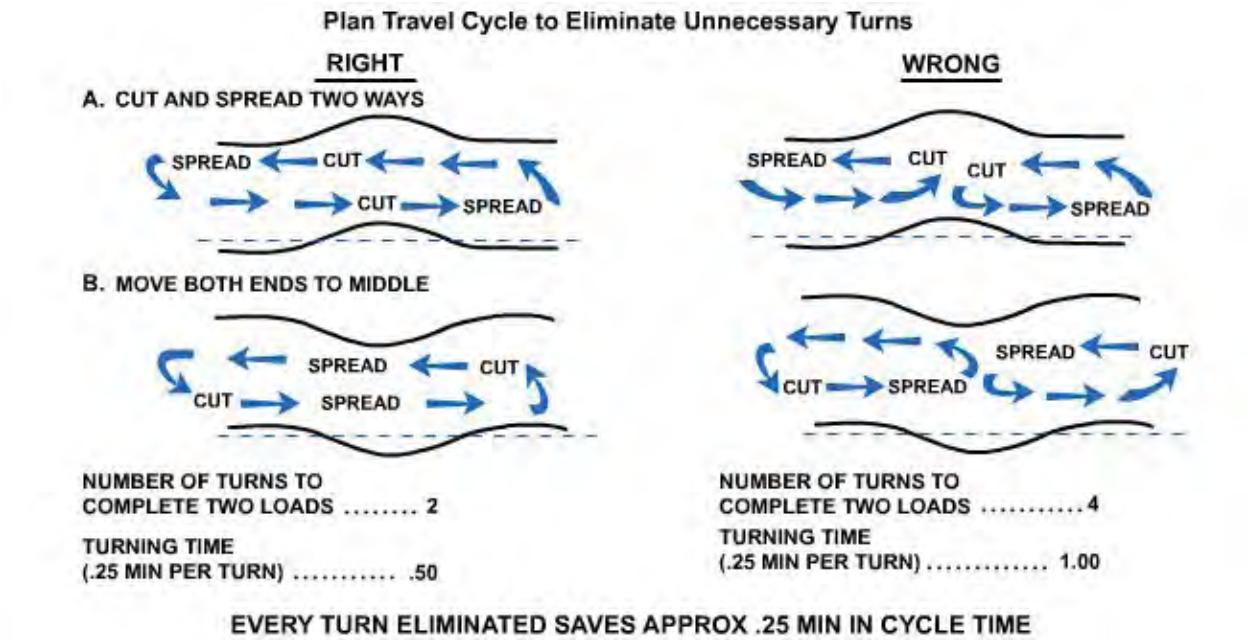


Figure 18-20 – Cut and spread sequence.

5.4.8 Haul Roads

Haul roads should be level and laid out so that time is not wasted maneuvering the scraper. Haul roads that have drastic changes in elevation reduce production. Keep them moist and in good condition. Roads that are moist (not wet) and packed into a hard, smooth surface permit higher traveling speeds, increase safety, and reduce operator fatigue and equipment wear. The moisture also controls the dust entering scraper parts and causing lubrication problems and premature wear. Additionally, controlling the dust allows better visibility.

If the haul road is a dirt road in need of grading, use the scraper's cutting edge to maintain it on returns back to the cut. Do this by opening the apron approximately 12 inches above the cutting edges with the ejector positioned forward within 6 inches of the

cutting edge. Lower the bowl until the cutting edges scrape about 1 to 2 inches of the road surface. By watching the road, you can vary the cutting action to trim small rises and carry the material to fill depressions as the scraper travels the haul road. Perform these grading operations in second or third gear, depending upon road conditions. Grading should be done only when the road surface has ruts and rough or soft spots.

NOTE

Scrapers on the haul road should travel only in the highest gear that is safe for the road.

5.4.9 Scraper Spacing Efficiently

Scrapers should be teamed by their speed whenever possible. The fastest scrapers should be assigned to one section of a job, while the slower ones are assigned to another. If possible, they should use different haul roads.

NOTE

No scraper can travel faster than the scraper ahead of it. Passing only increases the chance of accidents.

Scraper operators can help in traffic control by speeding up to close long gaps and slowing down when coming too close. Efficient spacing supports the optimum use of the push cat. During unloading operations, when lagging far behind the next scraper, spread the load at the beginning of a fill. When traveling too close to the next scraper, spread the load at the far end of the fill.

NOTE

Keep the scraper bowl as close to the ground as possible to lower its center of gravity and to keep it upright.

5.4.10 Spreading

Techniques for scraper spreading operations are as follows:

- Spread the first load at the start of the fill.
- Travel with subsequent loads over the previous fill, provided lifts are small.
- Start each following spread at the end of the previous layer.
- Finish spreading in one full length before starting a new lane, so rollers can begin compaction.
- Route the scrapers to compact the fill. Overlapping the scraper tire tracks aids in the compaction of the entire area and reduces the compaction time necessary with a roller.
- Spread in the highest gear permitted by the condition of the fill area terrain.

NOTE

Slowly discharging loads at low speed slows down production and cycle time.

- Do not waste time on the fill. As soon as the load is spread, get the scraper back on the haul road and return to the cut. Plan your exit from the fill to avoid soft ground and detours around trees and other obstacles.
- As shown in *Figure 18-21*, make the fill high on the outside edge. This prevents the scraper from sliding over the outside edge and helps maintain accurate slopes to desired heights. When the fill is not made in this manner, the scraper

tends to work away from the edge of the fill, making it hard to maintain the correct slope. In inclement weather, build up the center for drainage.

Figure 18-21 – Proper placement to fill material.

Test your Knowledge (Select the Correct Response)

8. A scraper work cycle has a total of how many phases of operation?

   A. One
   B. Two
   C. Three
   D. Four

6.0.0 SAFETY

Safety precautions that apply to scrapers are as follows:

- Never operate a scraper at speeds that are unsafe.
- Always wear seat belts. Uneven terrain can cause a violent tilt of the scraper, causing possible personal injury by throwing you off or against the steering wheel if not secured in the operator's seat.
- Block up the scraper bowl and apron before performing any work on the cutting edges of the scraper.
- Keep the operator's cab clear of debris, grease, oil, and mud, as they can cause the operator to slip or fall.
- Never kick the scraper out of gear when going downhill. The increased speed will make control of the scraper very difficult. Keep the scraper in gear at all times and use the cutting edge to control the speed. When the brakes fail to hold the load, lower and drag the scraper bowl.
- When securing the scraper, ensure the apron is closed and the bowl on the ground.
- Do NOT spread when turning.

- When working on slopes, always turn uphill.
- Do NOT drop the bowl suddenly; ease the cutting edge onto the ground.
- Load and spread when going downgrade, whenever possible.
- When constructing a fill, keep the outside edge high and the center low to prevent the scraper from sliding over the edge.
- When the scraper begins to fall off the fill, steer downhill, drop the bowl, and rapidly accelerate to maximum rpm. Do NOT attempt to turn the scraper back up the slope. Do NOT stop the forward motion of the scraper when there is any danger of the unit tipping over.
- Wear any required personal protective equipment, such as hard hats and steel toe safety shoes.

Test your Knowledge (Select the Correct Response)

9. **(True or False)** It is a safe practice to kick the scraper out of gear when going downhill.

   A. True
   B. False

Summary

Scrapers are large earthmovers designed to cut, self-load, and spread loose materials. This chapter introduced you to three types of scrapers used by the NCF: the single- and twin-engine scraper and the paddle wheel scraper. You were introduced to their major components, which include a tractor and scraper unit consisting of a bowl, apron and ejector. You were also introduced to the scraper's 4-phased work cycle as well as loading techniques that increase productivity by using two scrapers and a push cat. Last, you were introduced to safe practices.

Review Questions (Select the Correct Response)

1. What term is used to describe the type of dozer that pushes a scraper through heavy or consolidated material?

   A. Drive cat
   B. Push cat
   C. Thrust cat
   D. Shove cat

2. In what manner is material loaded in a paddle wheel scraper?

   A. Bottom loaded by a paddle wheel elevator
   B. Top loaded by a paddle wheel elevator
   C. Force loaded from the cutting edges
   D. Bottom loaded by screw augers

3. What component on a scraper permits the tractor and scraper to move independently from side to side?

   A. Vertical kingpin swivel
   B. Horizontal gooseneck
   C. Longitudinal horizontal hinge
   D. Vertical tip hinge

4. Which of the following types of equipment can be used to load a scraper?

   A. Crane clamshell
   B. Conveyor
   C. Front-end loader
   D. All of the above

5. **(True or False)** When closed, the apron rests on the side cutters.

   A. True
   B. False

6. Which of the following scraper components forms the rear wall of the bowl?

   A. Stinger
   B. Apron
   C. Ejector
   D. Paddle wheel

7. What component is supported by rollers riding on the floor and on tracks welded to the sides of the bowl?

   A. Stinger
   B. Apron
   C. Ejector
   D. Bowl stiffeners

8. On the Caterpillar 621B, how would an operator open the apron?

   A. Move the joystick left.
   B. Move the apron lever left.
   C. Move the joystick right.
   D. Move the apron lever right.

9. On the Caterpillar 621B, how would an operator push material out of the bowl?

   A. Move the joystick left.
   B. Move the joystick right.
   C. Move the ejector lever right.
   D. Move the ejector lever left.

10. Which of the following cutting edges penetrates more than the straight cutting edge?

    A. Curved
    B. Three-piece
    C. Stinger
    D. Pointed

11. When you are operating a scraper, what component must you properly engage to obtain maximum engine power output?

    A. Transmission gear ratio
    B. Differential lock
    C. Bogie drive shift lever
    D. Transfer case sprag unit

12. **(True or False)** Improper downshifting over speeds the transmission and engine, usually resulting in premature wear.

    A. True
    B. False

13. Downhill scraper speed should NOT exceed what maximum speed in miles per hour (mph) more than attained on level ground in the transmission ratio engaged?

    A. 20
    B. 15
    C. 10
    D. 5

14. Which of the following operations is NOT part of a scraper cycle time?

    A. Loading
    B. Hauling
    C. Refueling
    D. Unloading

15. To allow material to enter the bowl when loading a scraper, you should ensure the apron is opened by what number of inches above the cutting edge?

    A. Between 1 to 3
    B. Between 4 to 8
    C. Between 9 to 12
    D. Between 13 to 15

16. What term is used to describe a scraper bowl load that is filled to capacity?

    A. Struck
    B. Full
    C. Heaped
    D. Top

17. When traveling over a slippery haul road, you should carry the scraper bowl in what manner?

    A. As high as possible
    B. As low as possible
    C. About halfway between the highest and lowest position
    D. At the height the material is to be discharged

18. When a push cat is waiting for a scraper, it should be positioned at what degree angle off the lane to be cut?

    A. 90°
    B. 75°
    C. 45°
    D. 15°

19. After the apron opening has been adjusted and the dirt flowing through the opening lessens, you should engage which of the following levers to finish unloading the scraper bowl?

    A. Bowl
    B. Apron
    C. Ejector
    D. Power takeoff

20. A push cat operator must ensure that the reinforced section of the dozer blade is centered on what component of the scraper?

    A. Gooseneck
    B. Push block
    C. Spill guard
    D. Bowl stiffener

21. What term is used to describe the technique of obtaining a heap load of sand?

    A. Back-track loading
    B. Shuttle loading
    C. Optimum loading
    D. Pump loading

22. At the start of a pump loading operation, an operator should adjust the opening of the apron to how many feet?

    A. 1
    B. 2
    C. 3
    D. 4

23. **(True or False)** Oversize objects, such as large rocks, can cause damage to a scraper by denting, bending, or straining parts.

    A. True
    B. False

24. Which of the following types of loading techniques uses the force of gravity on the scraper to get larger loads in less time?

    A. High-speed
    B. Downhill
    C. Shuttle
    D. Straddle

25. When you are straddle loading, the island left between the first and second scraper cut should be what width, in feet?

    A. 4 to 5
    B. 10 to 12
    C. 15 to 20
    D. 25 to 30

26. Which of the following types of loading is used when it is possible to load in both directions?

    A. Downhill
    B. Straddle
    C. Back track
    D. Shuttle

27. During optimum loading operations, push-loaded scrapers should be loaded within 1 minute and within a maximum distance of how many feet?

    A. 25
    B. 50
    C. 75
    D. 100

28. **(True or False)** Scrapers on the haul road should travel only in the highest gear that is safe for the road.

    A. True
    B. False

29. In what manner should fills be constructed?

    A. Outside edge low and the center high
    B. Outside edge high and the center low
    C. Outside edge level with center
    D. Outside edge and center at a slope

30. Which of the following actions should you perform if a scraper begins to fall off a fill?

    A. Steer downhill
    B. Drop the bowl
    C. Accelerate rapidly
    D. All of the above

Terms Introduced in this Chapter

Trunnion (Walking beam or bar)	(1) An oscillating bar that allows changes in angle between a unit fastened to its center and another attached to both ends. (2) A heavy horizontal hinge.

Additional Resources and References

This chapter is intended to present thorough resources for task training. The following reference works are suggested for further study. This is optional material for continued education rather than for task training.

Apprentice Construction Equipment Operator, Volume 1 CDC 131, General Subjects and Contingency Responsibilities, Extension Course Institute, Gunter Air Force Base, Montgomery, AL 1984.

Earthmoving Operations, FM 5-434, Headquarters Department of the Army, Washington, DC, 2000.

Equipment Utilization, U.S. Army Subcourse EN5468, U.S. Army Engineer School, Fort Belvoir, VA, 1988.

Heavy Equipment Operations: Level Three, 2nd ed., National Center for Construction Education and Research, Gainesville, FL and Pearson Education, Inc., Upper Saddle River, NJ, 2006.

Nichols, Herbert L., Jr., *Moving the Earth*, 3rd ed., North Castle Books, Inc., Greenwich, CT, 1985.

Technical Manual for Scraper: Earthmoving, Motorized Diesel Engine Driven, Caterpillar 621B, Caterpillar Tractor Company, Peoria, IA, 1984.

CSFE Nonresident Training Course – User Update

CSFE makes every effort to keep their manuals up-to-date and free of technical errors. We appreciate your help in this process. If you have an idea for improving this manual, or if you find an error, a typographical mistake, or an inaccuracy in CSFE manuals, please write or email us, using this form or a photocopy. Be sure to include the exact chapter number, topic, detailed description, and correction, if applicable. Your input will be brought to the attention of the Technical Review Committee. Thank you for your assistance.

Write: CSFE N7A
3502 Goodspeed St.
Port Hueneme, CA 93130

FAX: 805/982-5508

E-mail: CSFE_NRTC@navy.mil

Rate____ Course Name_____

Revision Date_____ Chapter Number____ Page Number(s)_____

Description

_____

_____

_____

(Optional) Correction

_____

_____

_____

(Optional) Your Name and Address

_____

_____

_____

Chapter 19

Dozers

Topics

To hear audio, click on the box. 

Overview

The dozer, technically known as a crawler tractor, is used as a prime mover for pushing or pulling loads, a power unit for winch operations, or a dozer for earthwork operations and demolition work.

This chapter provides you the information needed to successfully execute such operations. It describes the types of dozers used by Naval Construction Force (NCF), including description of major components, controls, and attachments. In addition, this chapter explains how to perform operational techniques such as side-by-side and slot dozing. It also lists safety practices.

Objectives

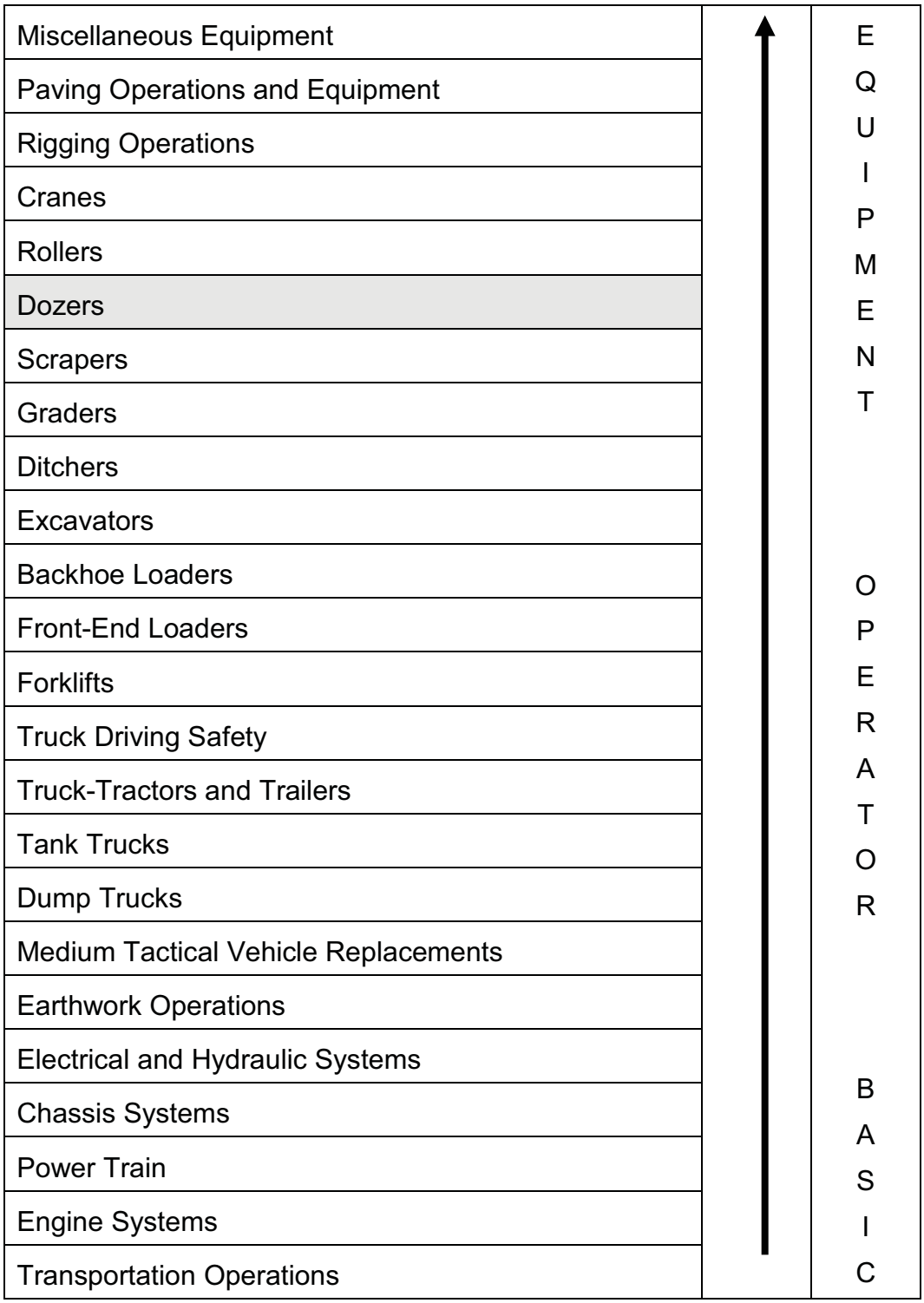
When you have completed this chapter, you will be able to do the following:

1. Understand the use of dozers.
2. Identify types of dozers used by NCF.
3. Identify the major components of dozers.
4. Identify the controls on the dozer.
5. Identify dozer attachments and their use.
6. Understand how to perform dozer operations.
7. Understand dozer safety.

Prerequisites

None

This course map shows all of the chapters in Equipment Operator Basic. The suggested training order begins at the bottom and proceeds up. Skill levels increase as you advance on the course map.



Features of This Manual

This manual has several features which make it easy to use online.

- Figure and table numbers in the text are italicized. The figure or table is either next to or below the text that refers to it.
- The first time a glossary term appears in the text, it is bold and italicized. When your cursor crosses over that word or phrase, a popup box displays with the appropriate definition.
- Audio and video clips are included in the text, with italicized instructions telling you where to click to activate it.
- Review questions that apply to a section are listed under the Test Your Knowledge banner at the end of the section. Select the answer you choose. If the answer is correct, you will be taken to the next section heading. If the answer is incorrect, you will be taken to the area in the chapter where the information is for review. When you have completed your review, select anywhere in that area to return to the review question. Try to answer the question again.
- Review questions are included at the end of this chapter. Select the answer you choose. If the answer is correct, you will be taken to the next question. If the answer is incorrect, you will be taken to the area in the chapter where the information is for review. When you have completed your review, select anywhere in that area to return to the review question. Try to answer the question again.

1.0.0 DOZERS

Dozers, also called bulldozers, are powerful diesel-powered crawler tractors equipped with a front mounted blade. Not only are dozers use to ***drift*** and side cast material, they are also used to clear land by moving debris, boulders, and trees. In addition, dozers are used to push and pull other heavy equipment.

Dozers are usually rated by size and power. The pull developed at the ***drawbar*** is expressed in pounds or as ***drawbar horsepower***. The ***drawbar pull*** is greatest in the lowest transmission gear range. Although the specifications for dozers may vary among different manufacturers, the maximum speeds are seldom in excess of 8 mph.

1.1.0 Types of Dozers Used By Naval Construction Forces

The NCF uses two types of dozers: the low and high track dozer.

1.1.1 Low Track Dozer

The low track dozer, like the one shown in *Figure 19-1*, is commonly used for grading.

Figure 19-1 – Low track dozer.

1.1.2 High Track Dozer

Designed with a high drive system, the high track dozer, shown in *Figure 19-2*, has an elevated drive sprocket. This specific type of dozer is commonly used for pushing in muddy conditions.

Figure 19-2 – High track dozer.

Test your Knowledge (Select the Correct Response)

1. **(True or False)** The high track dozer has an elevated drawbar.

   A. True
   B. False

2.0.0 MAJOR COMPONENTS

Major components vary among makes, models, and configurations. You are responsible for reading the operator's manual for specific information. For general understanding, *Figure 19-3* shows the major components of a Caterpillar D7G low track dozer.

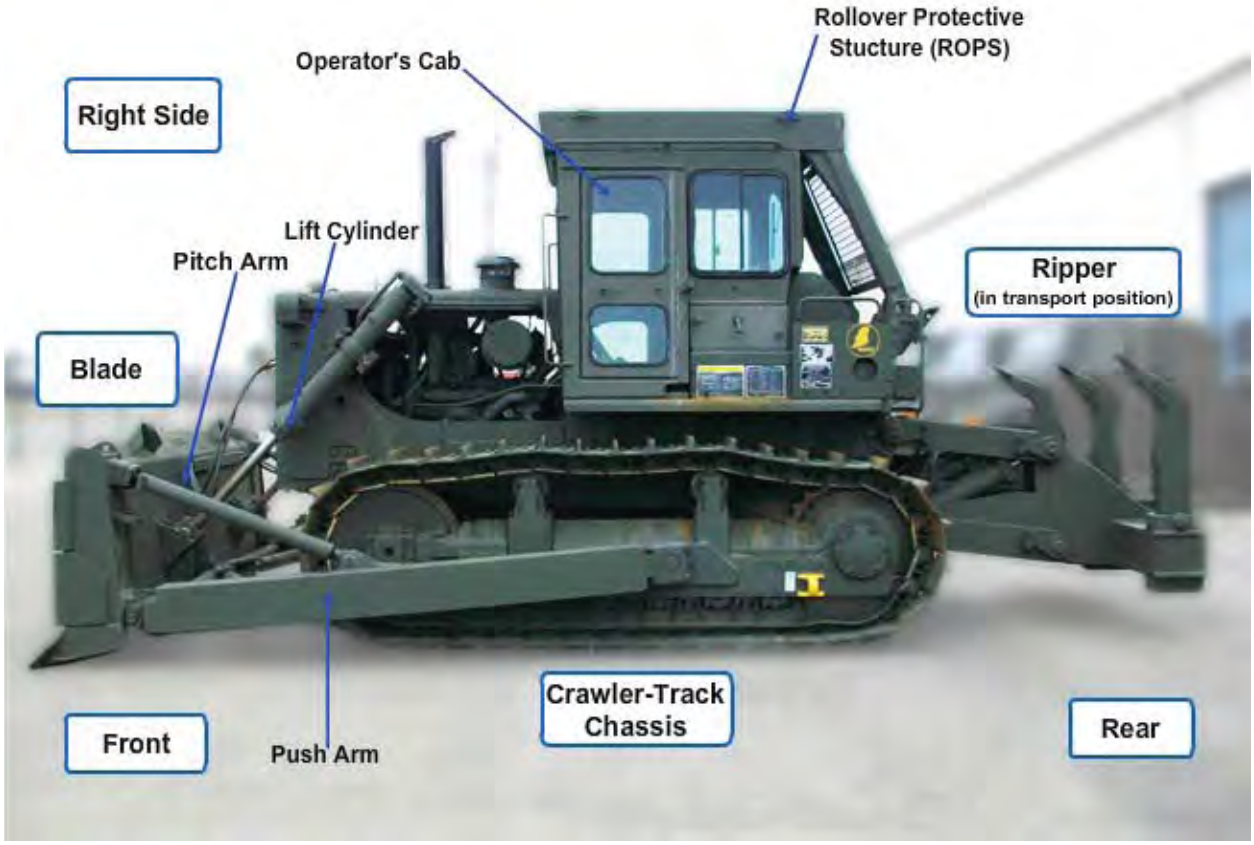


Figure 19-3 – Major components.

2.1.0 Operator's Cab

Mounted behind the engine, the operator's cab is the central location of most instruments and controls. Fully enclosed by a rollover protective structure (ROPS), the operator's cab provides the operator, instruments, and controls protection against harsh weather. The dozer's wide, side mounted tracks provide the operator a step for getting into and out of the operator's cab.

2.2.0 Track Assembly

The track assembly consists of a continuous chain surrounding the track frame and drive sprocket. The links of the chain provide a flat surface for the track rollers to pass over, as the rollers support the equipment. Track shoes are bolted to the outside of the chain links and distribute the weight of the equipment over a large surface.

The track assembly provides all-type-terrain versatility due to the low ***ground pressure*** at the track. This lower ground bearing pressure has a distinct flotation advantage over the ground bearing pressure of rubber-tired equipment. Dozers are capable of operating efficiently in muck or water as deep as the height of the track for short periods of time. When the dozer is properly waterproofed, it can operate in fairly deep water.

⚠ CAUTION ⚠

When working in water that is deep enough to reach the radiator, be sure to disconnect the fan belt. If the fan blades hit the water while under power, they could bend or break off, possibly causing damage to the radiator. Additionally, exercise extreme caution to ensure the engine does not overheat when the fan or water pump belts are disconnected.

If needed, dozers can move from jobsite to jobsite under their own power at slow speeds; however, this is a poor practice because it tends to shorten the operational life of the dozer. For this reason, dozers should be transported by tractor-trailer from jobsite to jobsite.

2.2.1 Track Chain

Figure 19-4 is a cutaway view of a section of track. It shows the internal arrangement of pins and bushings. As the dozer operates, the drive sprocket teeth contact the track pin bushings and propel the dozer along the track assembly. The pins and bushings wear much faster than other parts of the track because of their constant pivoting as the track rotates around the track frame. As the pins and bushings wear, the track lengthens. When this occurs, adjust the track to remove any slack.

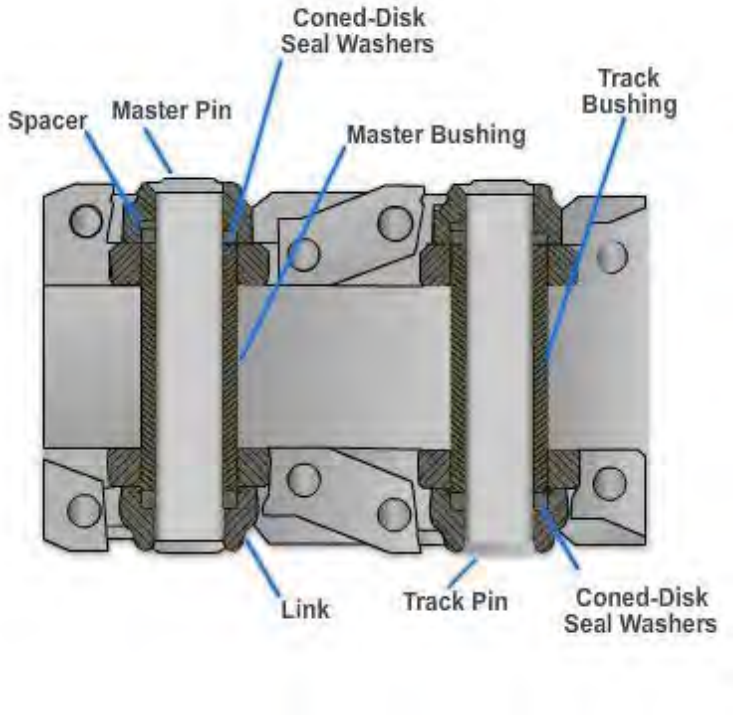


Figure 19-4 – Track chain.

Extensive wear on the outside of bushings is a good indication of inner wear. Manufacturers have set specifications for the maximum wear allowed before a track has to be rebuilt. To determine if a track should be removed for rebuilding or replacement, measure the outside of the bushings and track pitch (length of the track). Using a caliper and ruler, as shown in *Figure 19-5*, measure the outside of the bushing at the location at which it shows the most wear. Compare this measurement with the manufacturers' specifications. Measure the track pitch with a ruler or tape measure after tightening the track to remove any slack, as shown in *Figure 19-6*.

Figure 19-5 – Bushing wear measurement.

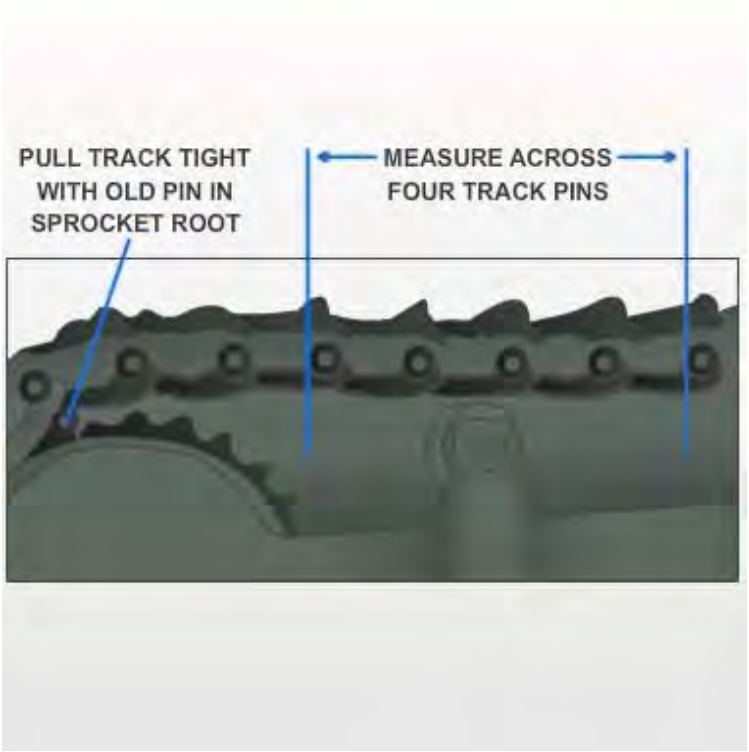


Figure 19-6 – Track pitch measurement.

2.2.2 Track Shoes

Track shoes are available in two configurations: the grouser shoe and extreme service track shoe.

The grouser shoe is the most common type of track shoe. It is standard on crawler-mounted dozers.

The extreme service track shoe, shown in *Figure 19-7*, is found on crawler-mounted dozers that operate primarily in rocky locations such as rock quarries and coral beaches.

The grouse, the projecting lug, on the extreme service track is thicker than the one on the standard grouser shoe; therefore it provides greater traction.

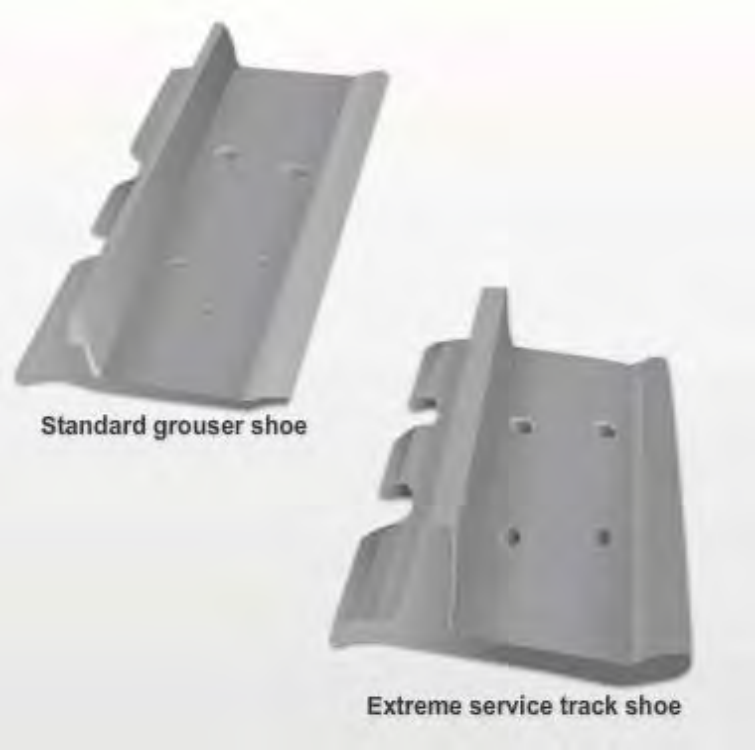


Figure 19-7 – Types of track shoes.

NOTE

The grouser absorbs most of the wear. Its condition can indicate when a track needs replacement or overhaul.

2.3.0 Track Frame

The track frame serves as a framework and support for the track assembly, rollers, front idler, recoil spring, and adjusting mechanism.

2.3.1 Track Frame Rollers

Two types of track frame rollers are used on tracked equipment: carriers and track rollers.

The carrier rollers are mounted on brackets that extend above the track frame. They support the track as it passes over the track frame assembly. Two carrier rollers are on each side of the dozer. The single flange on the rollers extends upward between the links of the track chain and keeps the chain in alignment between the drive sprocket and the front idler.

The track rollers are mounted on the lower portion of the track frame. They support the weight of the dozer and ensure the track chain is in alignment with the truck frame as the track passes under the rollers. Track rollers, both single and double flanged, are installed alternately. In the normal arrangement, a double-flanged roller is positioned directly in front of the rear drive sprocket, followed by a single-flanged roller. The rollers alternate forward to the front idler.

2.3.2 Front Idler

The front idler serves as a guiding support for the track chain. The idler is spring-loaded and mounted on slides, or guides, that allow it to move back and forth inside the track frame, as the dozer passes over uneven ground. The spring-loading effect causes the idler to maintain the desired tension regardless of operating conditions.

2.3.3 Recoil Spring

The recoil spring is a large coil spring placed in the track frame in a way that enables the spring to absorb shock from the front idler. The spring is compressed before installation and held in place by stops or spacers. The track adjusting mechanism, by pressing against the spring stop, maintains the desired tension on the track assembly by holding the idler and yoke in the forward position. The operation of the coil spring depends on the amount of tension on the truck.

2.3.4 Track Adjusting Mechanism

The adjusting mechanism must be extended enough to remove slack between the front idler and spring. The adjustment is made either manually, as shown in *Figure 19-8*, or hydraulically, as shown in *Figure 19-9*. Older model dozers have manual adjustments; whereas, newer dozers are adjusted hydraulically with a grease gun. Grease is pumped into the yoke cylinder and extends it until enough tension is placed on the recoil spring to remove the slack from the track. Tension is relieved by loosening the vent screw located next to the adjustment fitting.

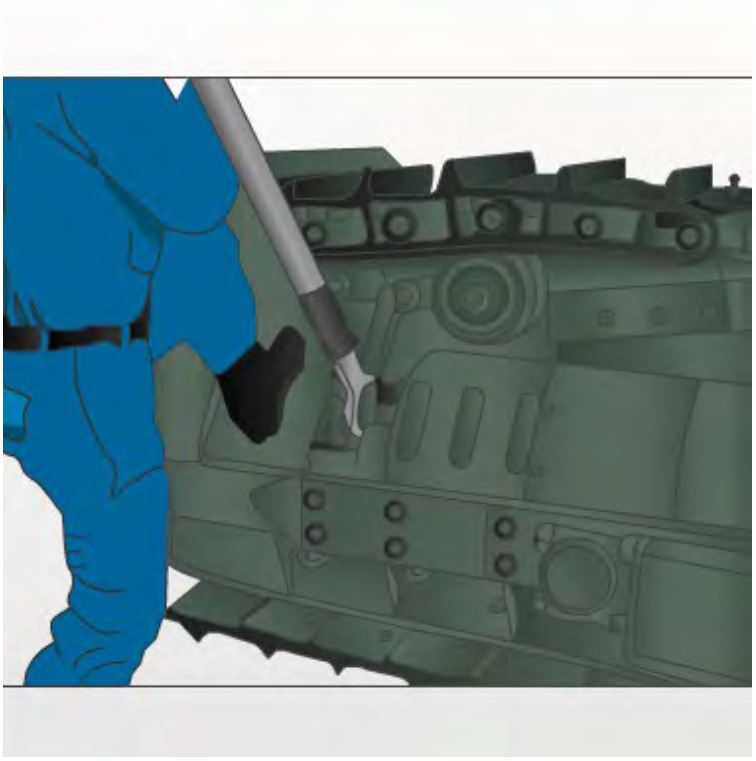


Figure 19-8 – Manual track adjustment.

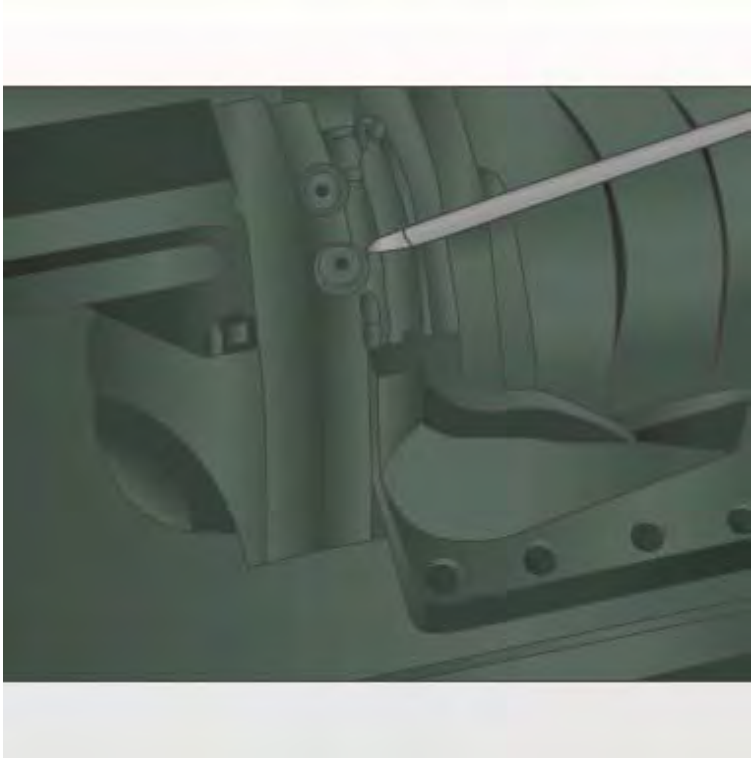


Figure 19-9 – Hydraulic track adjustment.

NOTE

Do not lubricate this fitting when performing daily operator's maintenance. Grease the track adjuster fitting only when the tracks require adjustment.

Track Adjustment – To determine proper track tension, position the dozer on a hard surface. Then place a straightedge over the front carrier roller and idler with all slack removed from the rest of the track. The tension is correct when the measured distance is as shown in *Figure 19-10*.

Track tension should be suitable for the type of area in which you are working, such as tighter for rock and looser for sand and snow. However, if the tracks are adjusted too tightly, there will be too much friction between the pins and bushings when the track links swivel, as they travel around the sprocket and front idler. This friction causes the pins, bushings, links, sprocket, and idler to wear rapidly. Friction in a tight track also robs the tractor of needed horsepower.

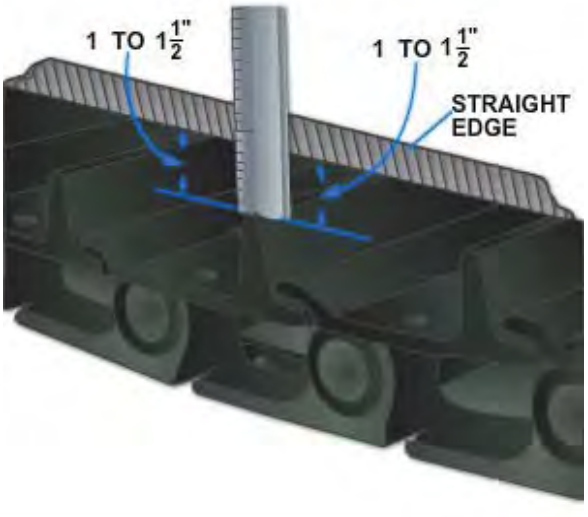


Figure 19-10 – Checking track adjustment.

Tracks that are too loose fail to stay aligned and tend to come off when the tractor is turned. As a result, the idler flanges, roller flanges, and the sides of the sprocket teeth wear down. A loose track will whip at high speeds, damaging the carrier rollers and their supports. If the track is loose enough, the drive sprockets will jump teeth (slide over the track bushings) when the tractor moves in reverse. Should this happen, the sprocket and bushings will wear rapidly.

NOTE

Checking and performing track adjustments are the operator's responsibility, always refer to the technical manual to perform the proper adjustment.

Lubrication – The track pins and bushings are hardened and require no lubrication. Many roller idlers are equipped with lifetime seals that are filled during assembly and require no lubrication. However, track rollers, carrier rollers, and idlers equipped with grease fittings must be lubricated on a schedule based on the manufacturer's specifications.

NOTE

Clean fittings before lubricating to prevent forcing dirt and grime into the bearings.

2.4.0 Blade

The blade is the dozer's primary working tool. Equipped with a bottom cutting edge and corner bits, it is used to drift and side cast material. The blade can be moved in many positions. Depending on the specific type of blade and dozer, the blade is manually or hydraulically positioned. It can be raised, lowered, tilted, pitched forward or back and angled so that one side is more forward than the other.

NOTE

Remember, checking the cutting edge and corner bits for wear is the operator's responsibility.

2.5.0 Push Arms

Most push arms are attached to the bottom of the blade. They may be located outside track frame at the trunnion or between the tractor and track.

2.6.0 Pitch Arms

Pitch arms are diagonal members between the push arm and the top of the blade. They brace the blade against loads above the push arms and provide a means of regulating the blade tilt and pitch. The pitch arms may be threaded or have a hydraulic cylinder, as shown earlier in *Figure 19-3*.

On the Caterpillar D7G the hydraulic pitch arm raises and lowers the right side of the blade. If additional tilt is required, the brace on the threaded pitch arm must be manually adjusted. Shorten the brace to make the left side of the blade lower; lengthen it to make the left side higher.

To pitch the blade forward, manually lengthen the brace and extend the hydraulic pitch arm. Use this pitch position when dozing extremely hard materials. To pitch the blade back, shorten the brace and retract the hydraulic pitch arm. Use this pitch position when leveling, spreading, or cleaning loose material without digging the blade in.

2.7.0 Ripper

The ripper is an attachment mounted on the rear of the dozer. It can be hydraulically raised and lower. On some dozers, it can be hydraulically adjusted for a greater ripping angle. It is used to break up compacted materials, uproot boulders and stumps; loosen shale, sandstone, and asphalt pavement; and rip up concrete slabs. After these materials are uprooted or ripped, supporting equipment can remove them more easily.

NOTE

Take care when turning with the ripper teeth in the ground; damage to the ripper teeth and assembly can occur.

Test your Knowledge (Select the Correct Response)

2. **(True or False)** The carrier rollers are mounted on the lower portion of the track frame.

   A. True
   B. False

3.0.0 CONTROLS

Control configuration depending upon the dozer's make and model. Some dozers have a set of levers, while others have joysticks to control vehicle movement and blade and attachment operation.

Figure 19-11 shows the set of levers on a Caterpillar D7G. The engine's speed is controlled by the governor, decelerator, and brake pedals. Because the Caterpillar D7G is a tracked dozer, its movement is controlled by a transmission control, a right and left steering clutch, and a brake control. Other controls include a blade lift and tilt control and a ripper height control.

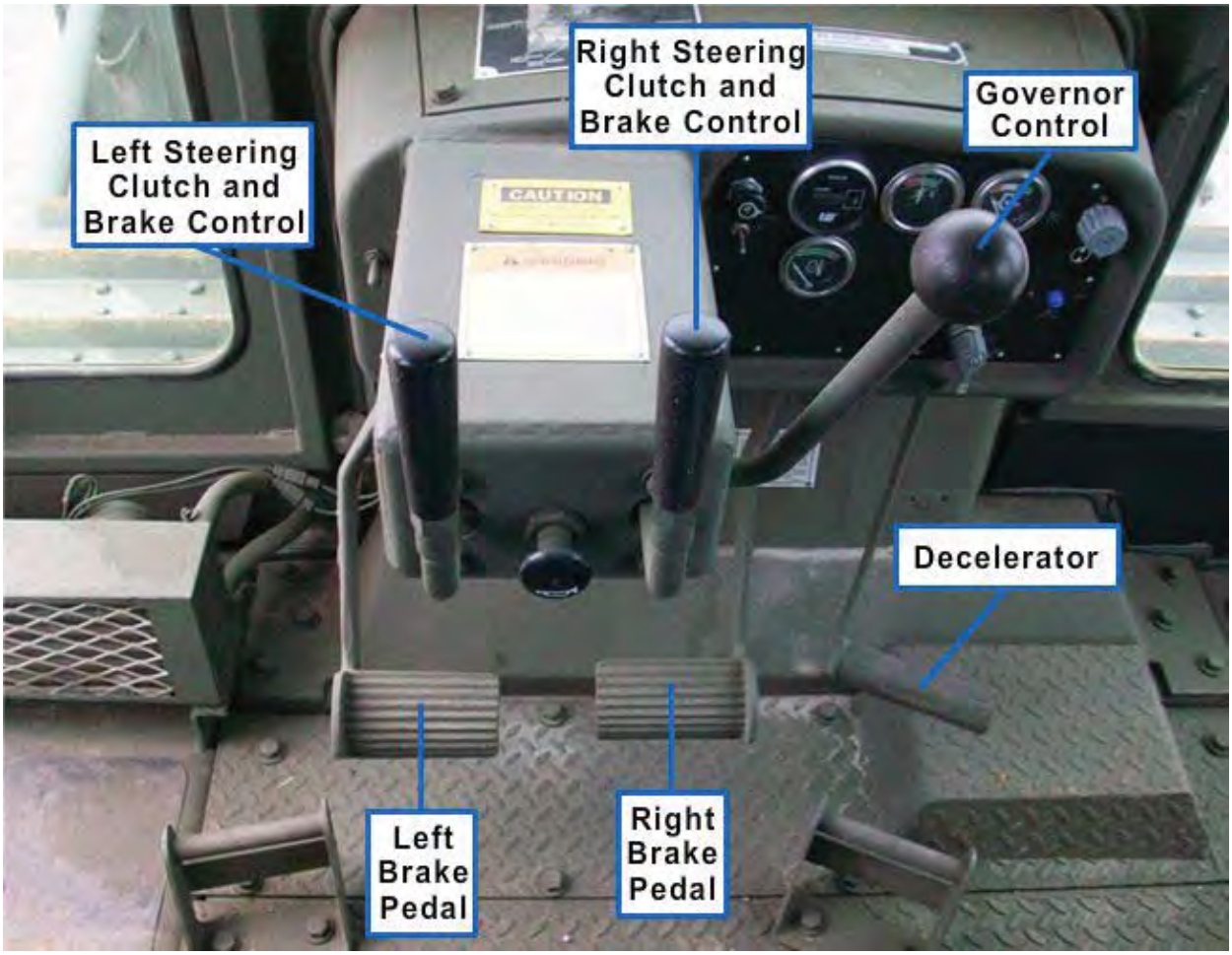


Figure 19-11 – Controls.

3.1.0 Blade Lift and Tilt Control

The blade lift and tilt control raises and lowers the blade as well as tilt the blade left or right. It can be moved forward, back or, and side to side. Its vertical positions are as follows: slightly and completely forward, center, and back. Its horizontal positions are left, center, and right.

- To lower the blade, slightly push the blade lift and tilt control forward.
- To float the blade, completely push the control forward.
- To raise the blade, pull the control back.
- To lower the left side of the blade, move the control left.
- To lower the right side of the blade, move the control right.
- To suspend the movement of the blade, move the control into the center position.

3.2.0 Ripper Height Control

The ripper height control raises and lowers the ripper. It can be moved forward, back, and side to side. Its vertical positions are forward, center, and back. Its horizontal positions are left, center, and right. The center position suspends the ripper's movement.

- To raise the ripper, move ripper height control left.
- To lower the ripper, move the control right.
- To suspend the movement of the ripper, move the control into the center position.

Figure 19-12 allows you to operate these two controls.

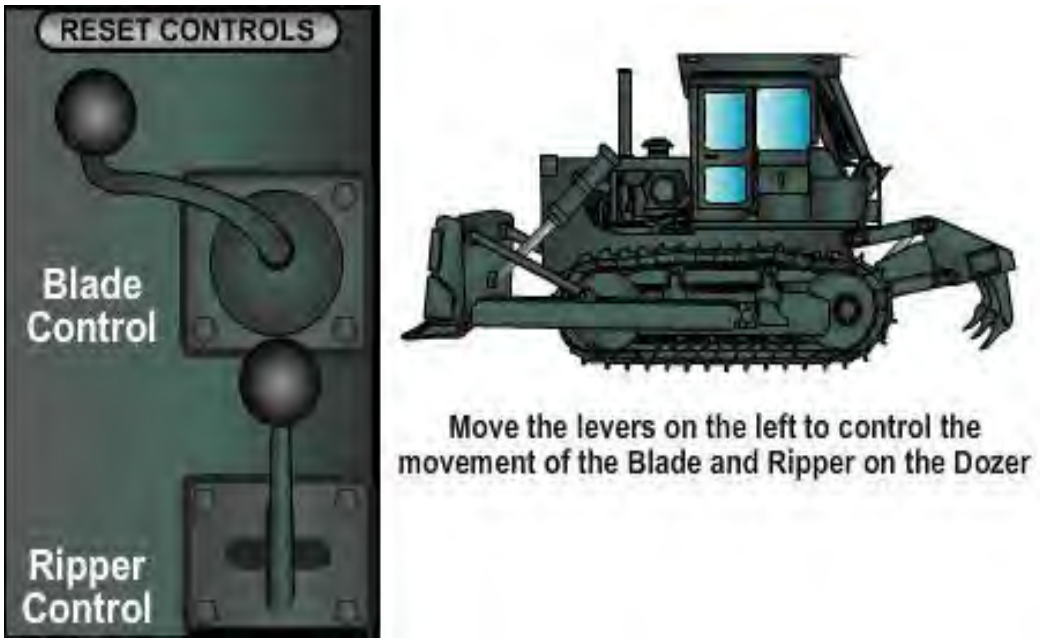


Figure 19-12 – Operating dozer controls.

Test your Knowledge (Select the Correct Response)

3. On the Caterpillar D7G, how would an operator raise the blade?

   A. Push the blade lift and tilt control slightly forward.
   B. Push blade lift and tilt control completely forward.
   C. Pull blade lift and tilt control back.
   D. Move blade lift and tilt control left.

4.0.0 ATTACHMENTS

Compared to other equipment, very few attachments are used with or on dozers. The attachments that are used include a variety of blade configurations and a rear mounted winch.

4.1.0 Blades

Blades vary in size and design based on specific work applications. Before using a blade, ensure that it is suitable for the specific type of dozer and work application for which you use it.

4.1.1 Straight Blade

The straight blade is ideal for general dozing when materials are to be drifted a short to medium distance (*Figure 19-13*). Blade curvature lifts the dirt high with a rolling action to lower resistance and speed drifting. These blades have the side advanced ahead of the center section, and they tilt up to 15 degrees, left or right.

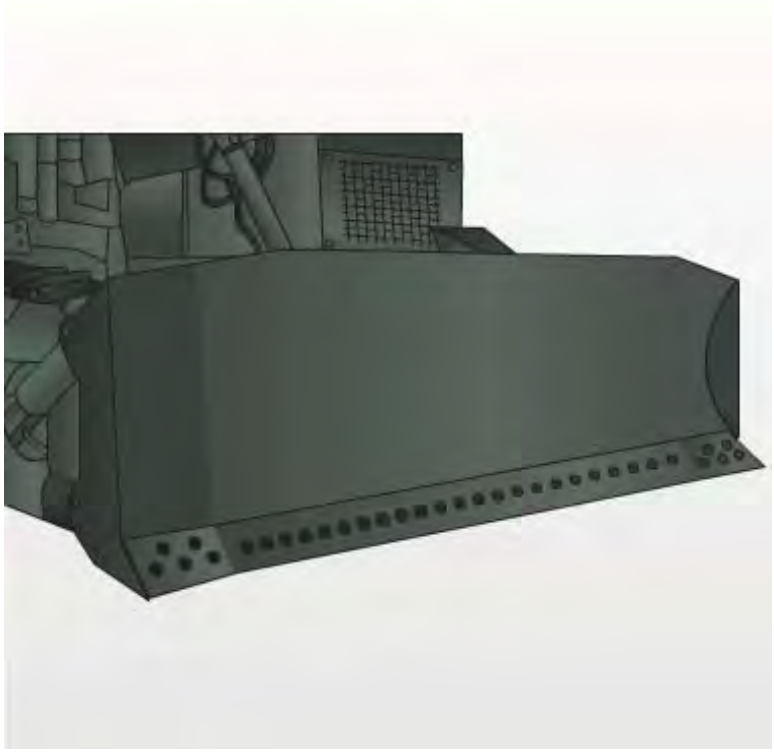


Figure 19-13 – Straight blade.

4.1.2 Angle Blade

The angle blade is a multipurpose tool that can be used for general dozing and for the side casting materials (*Figure 19-14*). The angle blade can be positioned straight ahead or angled 25 degrees to either side. The moldboard has a greater curve than a straight blade to produce more rolling action.

On dozers equipped with an angle blade, the-push arms are in a “C” frame configuration. The “C” frame is attached to the trunnions and wraps around the front of the dozer. The blade is attached to the “C” frame with a steel pin.

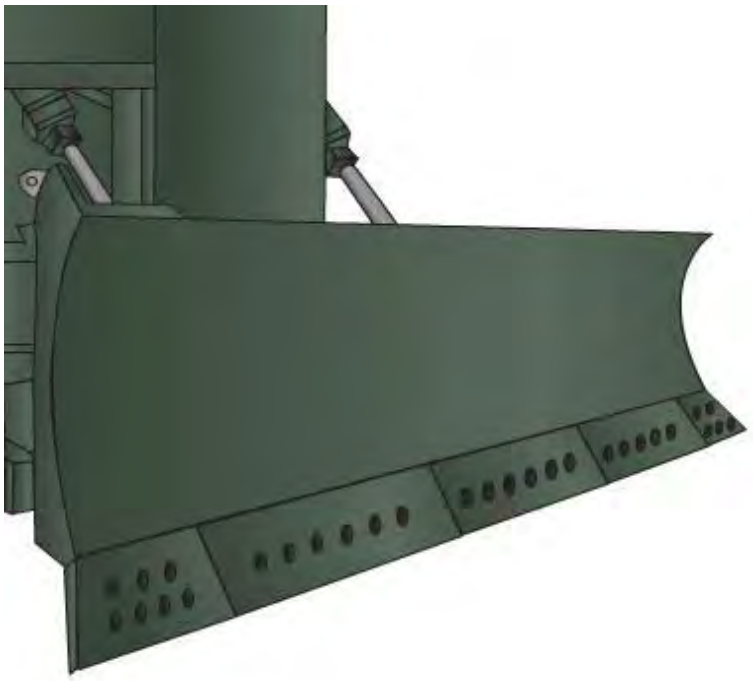


Figure 19-14 – Angle blade.

4.1.3 “U” Blade

The “U” blade shown in *Figure 19-15* drifts large volume loads efficiently over long distances. The center section lifts material high with a forward roll. The side sections are angled so they lift and roll materials inward, keeping the load centered with a minimum loss of material to the side. This type of blade has the sides well advanced ahead of the center section, causing a “U” shape. It may also be tilted 15 degrees, right or left.

Figure 19-15 – “U” blade.

4.2.0 Winch

A winch can be mounted on the rear of the dozer and is directly geared to the rear power takeoff (*Figure 19-16*). This arrangement permits development of a line pull 50 to 100 percent greater than straight dozer pull. The winch is used for uprooting trees and stumps, hoisting and skidding felled trees, freeing mired equipment, and supporting amphibious construction operations.

Some limitations to consider when performing winch operations are the pulling capacity of the winch and the size and weight of the dozer. Also, the terrain may affect maneuverability of the dozer.

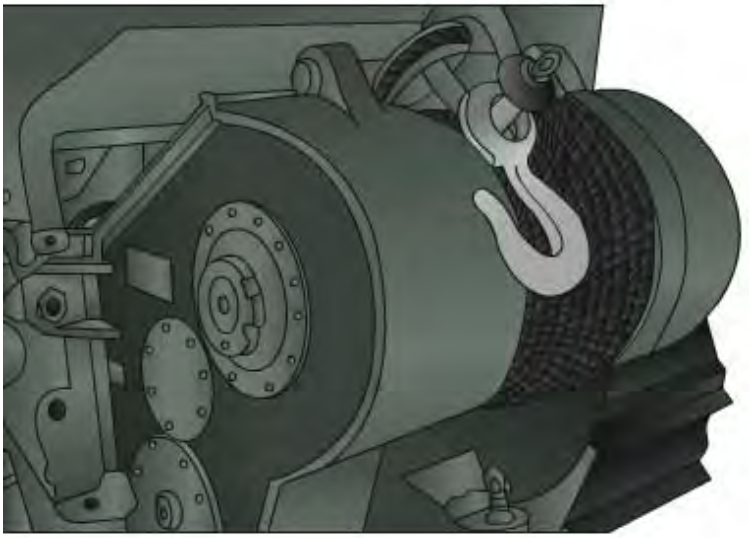


Figure 19-16 – Winch.

WARNING

Breakage of the wire rope is a serious hazard to both the operator and the helpers. Wire rope stretches under strain, and if it breaks, it whips with great force. The danger to the operator is greatest if the operator and dozer are in direct line with the wire rope when it is under strain. When the wire rope is under strain, everybody in the area should stand clear of the full length of the paid-out wire rope. When rewinding the wire rope back onto the winch drum, ensure riggers' hands are clear of the winch drum by at least 3 feet. Be safety conscious and ensure the wire rope used is of the best quality, meets the manufacturers' specifications, and is properly inspected before use. Always wear leather-palmed gloves when handling the wire rope.

A good practice is to work a winch at less than its maximum capacity and to avoid anchoring the dozer unless absolutely necessary. Moderate loads give long life to the wire rope and winch parts and avoid severe catching on the drum. If the work is heavy, strain can be reduced with pulleys and multiple lines. When pulling from the winch, always be sure to pull straight off the winch. When wire rope is pulled from an angle, it slips sideways, possibly causing damage to both the wire and winch.

Test your Knowledge (Select the Correct Response)

4. An angle blade can be angled to what amount of degrees to either side?

   A. 10°
   B. 15°
   C. 20°
   D. 25°

5.0.0 OPERATIONS

The dozer blade is hydraulically controlled by a lever or a joystick inside the operator's cab. Before starting, raise and lower the blade several times to get a feel for the hydraulic control. Start all jobs, if possible, from relatively level ground. If necessary, level an area large enough to provide sufficient working space for the dozer. This prevents back-and-forth pitching of the dozer and results in better blade control.

Avoid track spinning whenever possible; this wastes effort and only converts a relatively smooth working area into ruts and piles of material that pitch and tilt the dozer. In cold weather, ruts and piles freeze and cause additional difficulty the following workday. If it rains, the ruts hold the water, resulting in wet, muddy material.

Ditches, ridges, rocks, or logs should be crossed slowly and, if possible, at an angle. This procedure slows the fall, lessens the danger of upsetting the dozer, and reduces the jolt of the fall, which can harm both operator and dozer.

When dozing, shift the dozer into low gear and lower the blade into the ground gradually until obtaining the desired depth of the cut. When you feel an increase in resistance as the load culminates, start raising the blade in small increments, about one-quarter inch at a time. If you raise and lower the blade as much as 2 or 3 inches at a time while operating, the blade will cut an uneven surface, which the dozer must travel over. The uneven surface will cause the dozer to nose up and down, resulting in a greater uneven cut and up-and-down movement of the dozer.

To push the load with the blade, you must anticipate and compensate for the up-and-down movement of the front of the dozer. When the front of the dozer starts to nose up, move the control lever in the direction that will lower the blade. When the dozer starts to nose down, raise the blade high enough to compensate for the lowering of the front of the dozer. Do not over control. Raise and lower the blade only enough to compensate for the raising and lowering of the front of the tractor. Through experience, you will be able to raise and lower the blade automatically without giving it much thought or special attention.

5.1.0 Clearing

Clearing consists of removing brush, trees, and rubbish from a designated area. Also remove surface boulders and other material that may be embedded into the ground, as well as any material that may interfere with the construction project.

5.1.1 Brush and Trees

To clear brush and small trees with a dozer, travel forward at a slow speed with the blade lowered several inches below grade, as shown in *Figure 19-17*. To clear in this manner, make one pass to knock over small trees and brush, and then make another pass to clear them away.

Figure 19-17 – Clearing brush and small trees.

5.1.2 Medium Trees

Medium trees are 4 to 10 inches in diameter. To push trees of this size, raise the blade as high as possible to gain added leverage and push the tree over slowly, as shown in *Figure 19-18*. As the tree falls, back up quickly to clear the rising root mass. Lower the blade, travel forward, and dig the roots free with a lifting and pushing action. The ***felled*** trees are then ready to be pushed to a dismissal area.

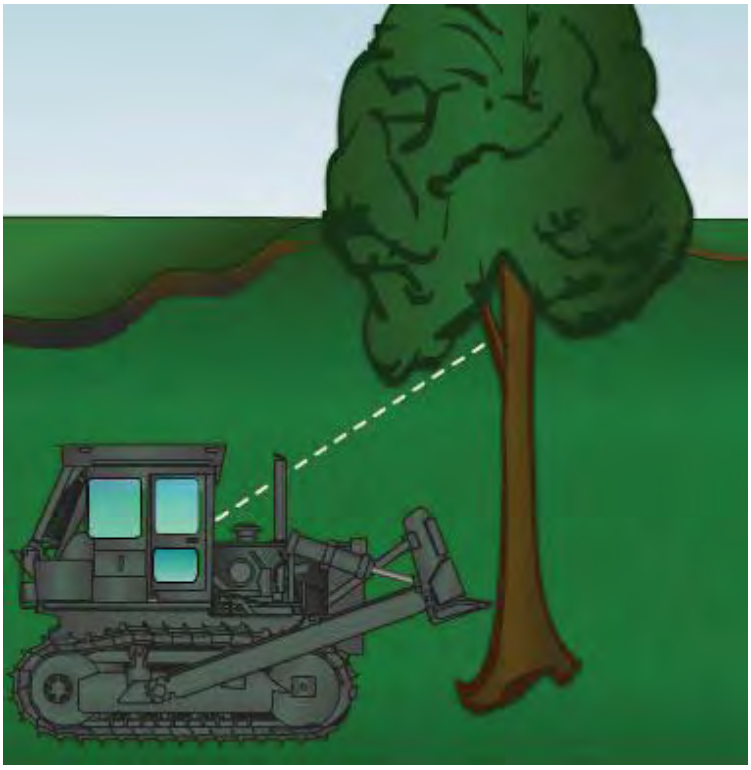


Figure 19-18 – Pushing over a medium-size tree.

5.1.3 Large Trees

Large trees are over 10 inches in diameter. The removal of large trees is more difficult and takes more time. Approach the tree on foot and inspect it for dead limbs that can break off and fall onto the dozer, possibly hitting the operator. Then make sure the dozer blade contacts the tree high and centered for the most leverage. Before pushing over a large tree, determine the direction of the fall, usually the direction of its lean. If the tree can be pushed over in the manner described for medium trees, do so.

If the tree has a large root system, use the following method:

- Make a cut on the opposite side of the proposed direction of fall. The cut should be deep enough to sever some of the larger roots.
- Make a cut on both adjacent sides in the same manner.
- Build an earth ramp on the same side of the original cut to obtain a greater pushing leverage.
- As the tree starts to fall, backup quickly to clear the rising root mass.
- After the tree has fallen fill the stump hole so that water cannot collect.

These steps are shown in *Figure 19-19*.

Figure 19-19 – Removing a large tree.

To remove large-or well rooted trees, it may be necessary to cut the roots on the fourth side. The cut around the tree should have a “V” ditch shape, made with the blade angled downward laterally toward the tree to cut the roots.

CAUTION

When removing trees, be careful not to injure personnel or damage equipment. Ensure that the dozer had side covers around its engine. These covers help prevent limbs, sticks, and other debris from entering the engine area.

When clearing trees, dozers should never work closely together because one dozer could push a tree over on the other.

Do not follow too closely when the tree starts to fall because the stump can get caught under the front of the dozer, resulting in difficulty backing up and damage to the bottom of the dozer.

As the operator, you should have a plan for clearing trees so that they do not become entangled with one another when they fall.

You will probably be clearing green trees. When free, green trees bend and snap back, potentially damaging equipment and injuring personnel. When making contact or releasing pressure, do it slowly so that the top of the tree does not sway or shake causing dead limbs to break off and fall on the dozer and possibility hit you.

Know the ground on which you are working. Do not high center the dozer on stumps or trees. This problem is tougher when you are working in a wooded area and need help from another dozer. Existing tress could interfere. When you are clearing brush and trees, remember that the most common cause of damage to a machine is a stick or limb puncturing the radiator, breaking a hydraulic line, or damaging the exhaust stack. Pay attention. Know the capabilities of you dozer and what you need to do from start to finish.

5.2.0 Stumping

Pushing down a whole tree with a dozer is easier than removing a tree by cutting it down and then removing its stump. The stump is usually too short to gain any pushing leverage or provide a good sway action for breaking out the roots.

For a stump that will not yield to dozing, one option is to haul it out with chains and grab hooks pulled by several dozers. Another option is to haul the stump out by a wire leading to the winch on a winch-equipped dozer. If the ground around the stump is not to be disturbed, rather than removing it entirely, you may only need to saw the stump level with the surface grade.

5.3.0 Removing Rocks and Boulders

A dozer with a tilted blade is the most effective piece of equipment for removing rocks and boulders. With the left lower corner of the blade hooked well under the boulder, the best way to exert maximum uprooting pressure is to combine raising the blade with a right turn of the dozer. With the right lower corner of the blade hooked well under the boulder, the best way to exert maximum uprooting pressure is to combine raising the blade with a left turn of the dozer. A boulder that is deeply embedded should be side cut, like stump. Like some stumps, some boulders must be broken up other way before removal.

If the dozer is not equipped with a hydraulic tilt control, the blade can be tilted by adjusting the pitch braces to lower either corner. To increase the digging action of a straight-blade dozer working in hard ground, pitch the top of the blade forward.

5.4.0 Working in Wet Material

Wet material is quite difficult to move with a dozer. When the material is too soft to hold up the weight of the dozer, each successive pass should be the full depth of the wet material. This places the dozer on a firmer footing. Push the mud far enough so it will not flow back into the cut. Arrange for rescue in case the dozer becomes stuck.

NOTE

When rescuing a dozer, never hook onto the blade to pull the dozer forward. The blade is made for pushing, not pulling. Instead, hook the towing wire rope to the hook located under the front of the dozer or to the drawbar on the rear of the dozer.

Some dozers are equipped with wider track shoes for better flotation when working in mud or soft materials. These tractors with wide track shoes are called low ground pressure (LGP) tractors.

Extremely low ground bearing pressure is one of many reasons the dozer is highly recommended for working in wet material.

5.5.0 Bulldozing

Bulldozing (drifting) is the process of pushing materials straight ahead in front of the dozer blade. Bulldozing is most efficient when the blade pushes as much material as possible, as shown in *Figure 19-20*. The maximum working distance depends on the dozer's speed and blade's capacity; however, the maximum distance is usually 200 to 500 feet with 300 feet being normal for a medium-sized dozer.

Figure 19-20 – Bulldozing.

To maximize the amount of material pushed, push downhill whenever possible. With the assistance of gravity, a dozer can push a far greater load downhill than on a level grade. When bulldozing down a steep hill, a separate full-length pass with each load is unnecessary; instead, push and pile several loads at the brink of the hill and push them all to the bottom in a single pass.

Side-by-side and slot dozing are two techniques that maximize the amount of earth drifted by reducing and preventing spillage around the outer edges of the blade.

5.5.1 Side-By-Side

Side-by-side dozing, as shown in *Figure 19-21*, consists of two dozers working next to each other with blade edges as close together as possible. This technique prevents spillage around one blade edge on each dozer. Side-by-side dozing is time-consuming; therefore, it is impractical for hauls that are less than 50 feet and more than 300 feet.

Figure 19-21 –Side-by-side dozing.

5.5.2 Slot Dozing

Slot dozing is done by first building a pair of windrows with the spillage of several passes. As shown in *Figure 19-22*, the windrows serve as barriers to prevent spillage around the dozer blade ends. Under favorable conditions, slot dozing can increase production up to 50 percent.

Figure 19-22 – Slot dozing.

5.6.0 Spreading

As shown in *Figure 19-23*, dozers are ideal for spreading fill material brought in by haul units. Position the blade in a straight position, so the material is drifted directly under the cutting edge.

Figure 19-23 – Spreading.

5.7.0 Backfilling

When backfilling a culvert, do not cross the culvert with the dozer unless there is at least 12 inches of compacted material on top of the culvert, as shown in *Figure 19-24*. If you use a bulldozer to backfill a culvert, the best method is to make diagonal passes over the material, ending each pass with a swing that brings the blade in line with the culvert.

The angle blade is preferred for backfilling a trench, because it can side cast material into the trench while maintaining a steady forward motion, as shown in *Figure 19-25*.

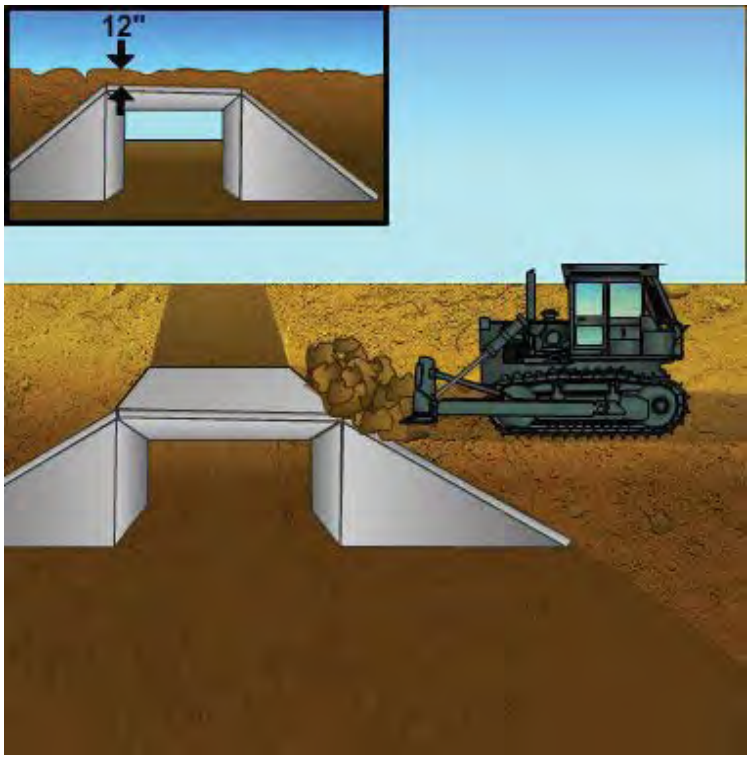


Figure 19-24 – Culvert backfilling.

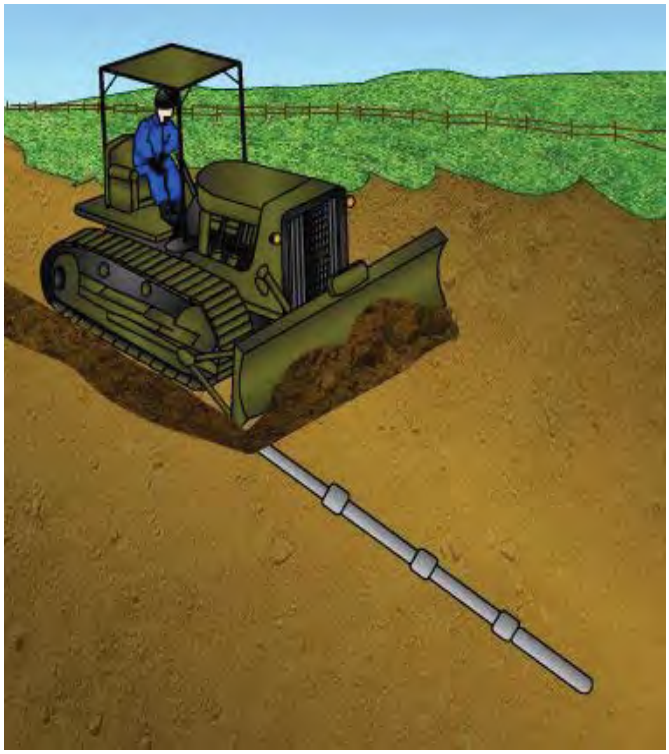


Figure 19-25 – Trench backfilling.

When a pipe trench is backfilled, fine material is placed around the pipe and coarse material above it, so the pipe is supported by well-compacted material. However, covering the pipe to full depth in short lengths may concentrate weight and break pipe joints; therefore, cover the pipe in successive layers, rather than all at once.

NOTE

Be careful in pipe trench backfilling to avoid dropping large rocks directly on the pipe.

5.8.0 Finishing

Whether clearing or spreading material on a roadbed, no job is completed until it has been smoothed and drainage is established. This is called finishing and should be done at the end of each shift.

Lightly blade over the surface with about a half a blade of dirt. This fills in any low spots or holes. Leave a windrow on the side that you are working toward. At the start of the next pass, cover half the blade width. Continue in this fashion over the project or section of the project you have worked that day before you shut down for the day. Finishing the project in this manner supports drainage and prevents having to walk over piles of dirt or through mudholes.

5.8.0 Ditching

Rough ditching can be done using a dozer by making a series of overlapping passes at right angles to the line of the ditch.

Figure 19-26 shows the construction of a V-type ditch. First, build a windrow along the edge of the ditch. Then, position the machine parallel to the ditch with the outside track on the windrow. Make a pass along the windrow. With the track elevated by the windrow, the blade cuts one side of the ditch. Cut the other side the same way.

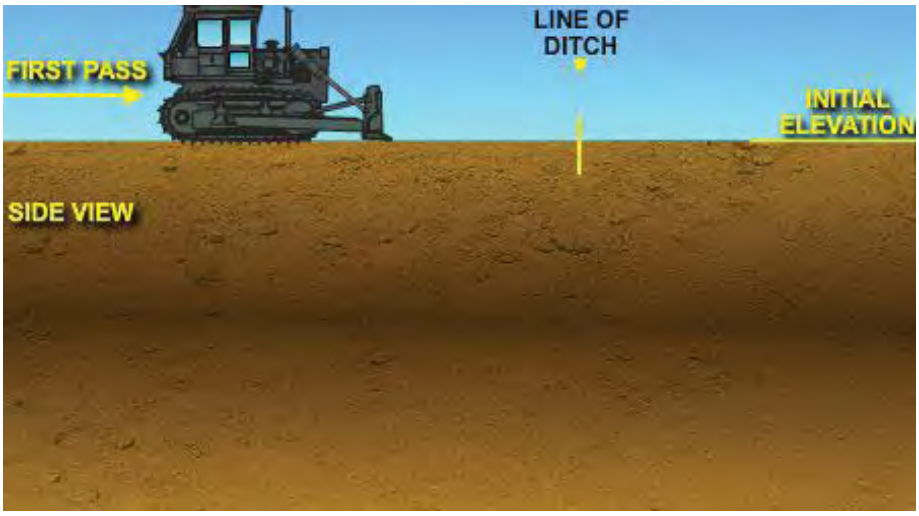


Figure 19-26 – Constructing a V-type ditch.

An angled blade is preferable for digging a V-type of ditch for two reasons. You can side cast the windrow in a single pass and the angled blade will side cast the material to the sides of the ditch as you travel along the windrow, as shown in *Figure 19-27*.

Figure 19-27 – Angle blade ditch cut.

5.9.0 Sidehill Excavation

A sidehill excavation can be started more easily if a small bench cut is made first, as shown in *Figure 19-2*8 a windrow will be created with the material removed from the bench cut. When digging the sidehill, keep the inside (uphill) surface slightly lower to gain greater tractor stability (*Figure 19-29*).Tilting the blade produces this type of cut.

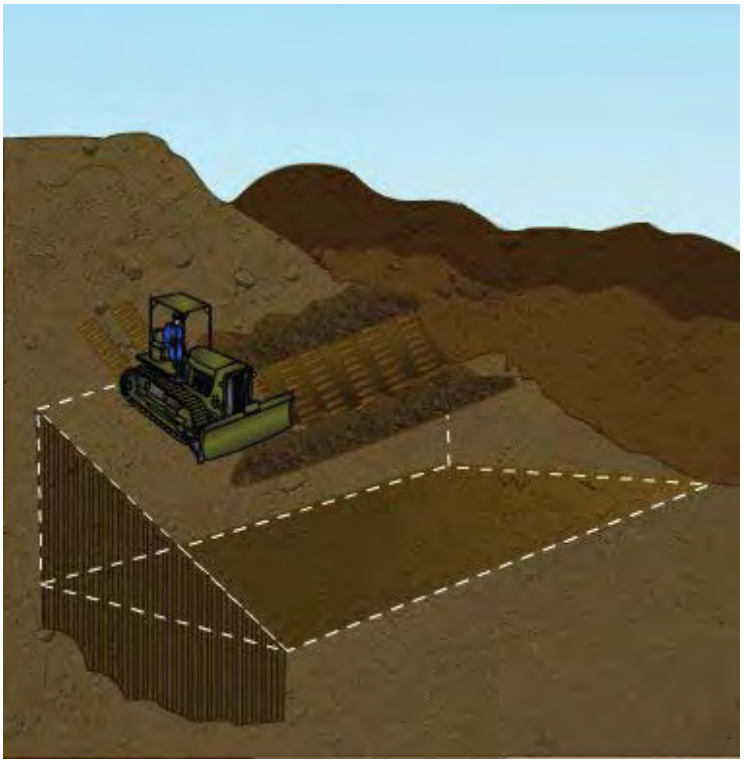


Figure 19-28 – Bench cut.

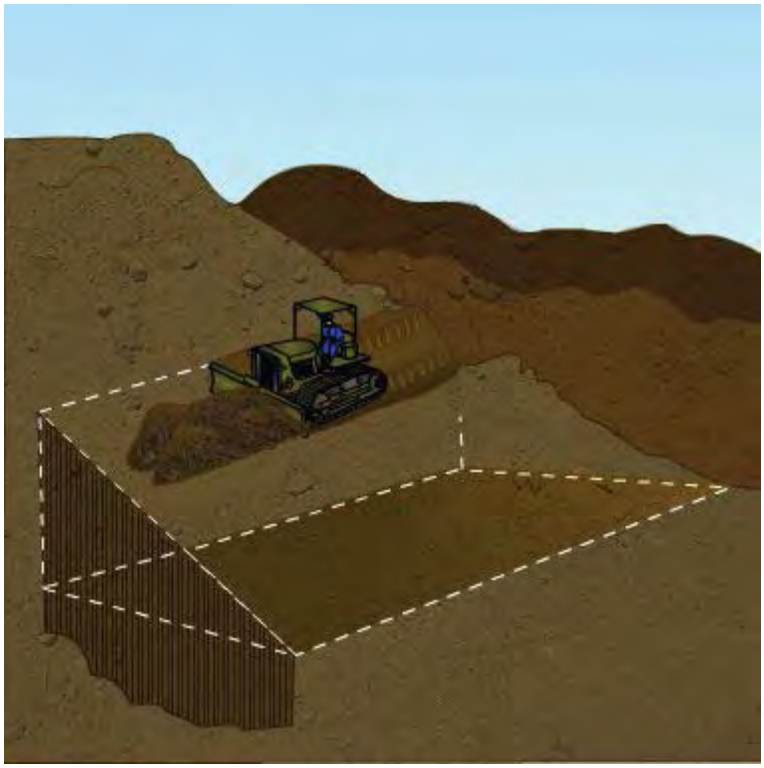


Figure 19-29 – Sidehill excavation.

Always cut the shelf wide enough to provide solid support for equipment that will be used later. If possible, move the material downhill to gain the advantage of gravity, reduce effort, and increase the stability of the dozer.

On shallow slopes or in soft soil, the sidehill cut can be made, as shown in *Figure 19-30,* cuts 1 and 2.

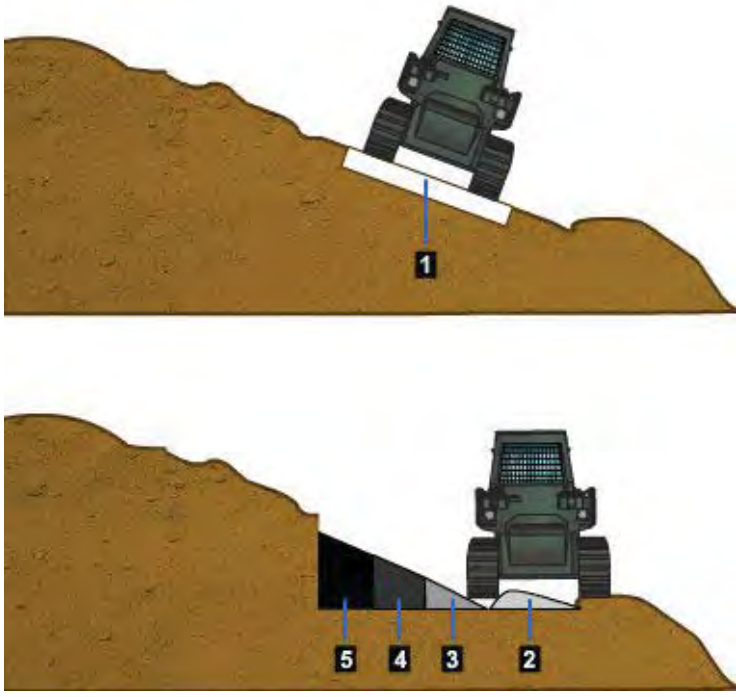


Figure 19-30 – Shallow slope sidehill excavation.

Running the uphill track inside the ridge left by the first cut increases stability. Pushing the loosened material to the lower side of the slope normally reduces the time required to complete the cut. In *Figure 19-30*, cuts 3, 4, and 5 show the completion of the shelf. Pushing the loosened material to the lower side of the slope normally reduces the time required to complete the cut. Do not push the material beyond the point required to retain firm track support. When you are backing up, do not raise the blade, as this puts extra weight on the front idlers, causing greater track penetration. Let the blade float as you back away from the edge of soft fills.

5.10.0 Finishing Side Slopes

There are two methods for finishing side slopes with dozer. One is to start at the top of the slope and work parallel to the right-of-way, as shown in *Figure 19-31.* Doing so will cause the material from each pass to fall to the lower side of the blade and form a windrow that can be picked up on the succeeding passes, filling irregularities in the terrain. When performing this method, do not allow the blade corner to dig, since this steepens the slope beyond job specifications.

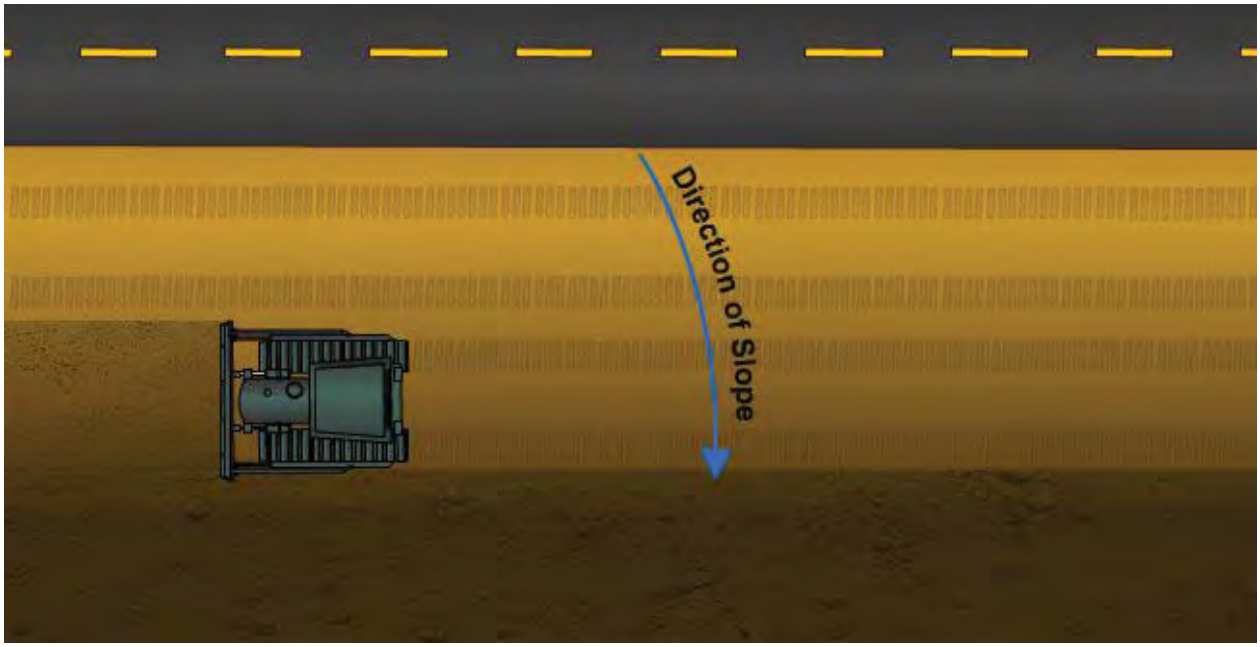


Figure 19-31 – Finishing a side slope by working parallel to the right-of-way.

The other method is to start at the bottom of the slope and work diagonally up (*Figure 19-32*). This method will form a windrow that is continually drifted to one side, filling low spots or irregularities.

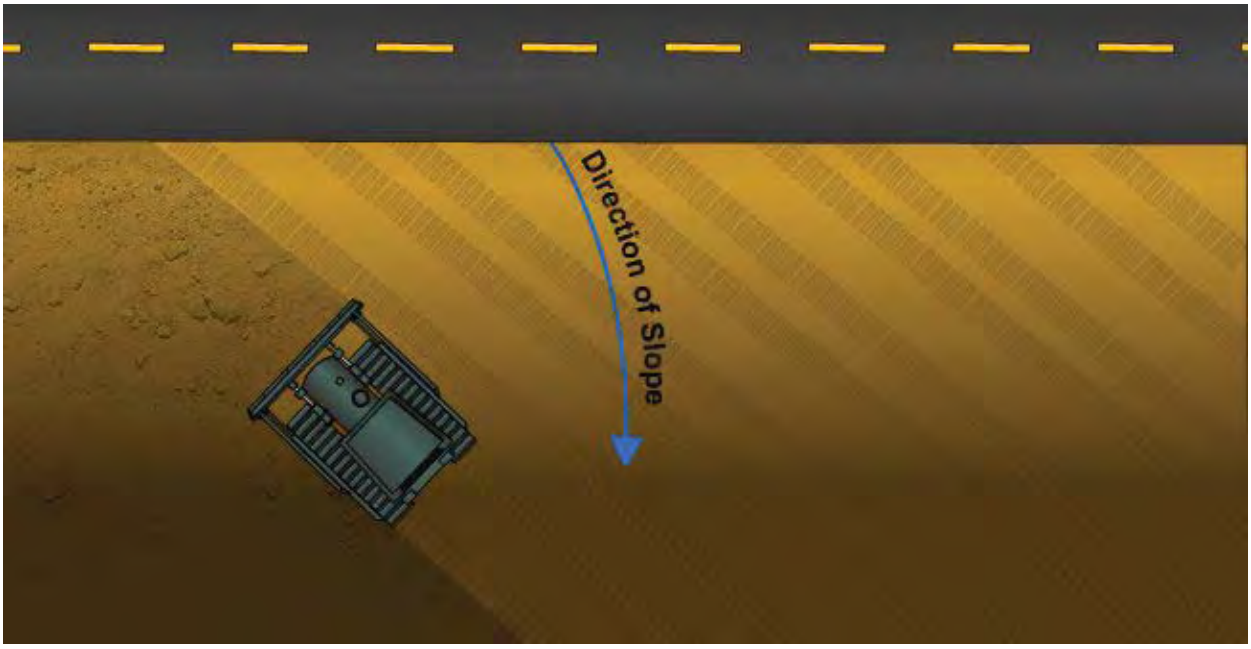


Figure 19-32 – Finishing a side slope by working diagonally.

NOTE

Diagonally finishing a side slope is one of few instances when a dozer may be used efficiently in cutting upgrade.

5.11.0 Pushing Dozer

The push dozer in *Figure 19-33* is equipped with a push blade. However, in most cases, a straight-blade dozer with a reinforced block in the center of the blade is used. Ensure the center lines of the pusher and scraper are aligned. If the alignment is not centered, it is hard to keep the pusher straight without extensive use of the steering clutch. When you are using the steering clutch, power is taken away from one track, and the other track is doing all the work. If the scraper starts to jackknife, stop pushing; back up, and get repositioned straight with the scraper. Be sure the blade of the dozer does not cut the rear tires of the scraper, resulting in downtime and costly tire replacement.

Figure 19-33 – Push dozer.

Test your Knowledge (Select the Correct Response)

5. What term is used to describe the operation of removing brush, trees, and rubbish from a designated area?

   A. Bulldozing
   B. Stumping
   C. Clearing
   D. Ditching

6. What is the most effective piece of equipment for removing rocks and boulders?

   A. A dozer with a tilted blade
   B. A rock drill
   C. A forklift
   D. A jackhammer

6.0.0 SAFETY

Standard safety precautions that apply to dozer operations are as follows:

- Only operate the dozer at speeds at which you can maintain control of the dozer at all times.
- Navy safety regulations require that all dozers be equipped with ROPS, crankcase guards, and radiator protectors. All dozers purchased by the Navy are equipped with these devices. Never use dozers without these devices.
- Always wear a seat belt when dozing. A sudden jolt from working on uneven terrain can possibly throw you off the machine or against the control levers, causing serious injury or death.
- Obtain a digging permit before performing excavation operations with a dozer.

- When using a dozer for demolition, take care to prevent falling objects from striking the operator or other personnel.
- When felling trees with a dozer, take care to avoid being struck by falling branches or by the backlash of a branch or trunk.
- Never use a dozer for clearing trees unless it is equipped with an operator's protective cage (brush cage).
- Personnel must never ride the dozer drawbar. This dangerous practice has been the cause of numerous accidents.
- Operators of dozer equipped with rippers should make every effort to learn the locations of any underground high-voltage electric lines or gas lines.
- Operate the dozer from the sitting position, never from a standing position.
- Operate a dozer with extreme care when near the edge of a cut; the edge may give way, overturning the machine.
- Climb a steep incline slowly. "Gunning" up a steep slope has often caused dozers to overturn.
- Do NOT attempt a turn on a steep slope. Sliding sideways may not appear to be dangerous, but it can easily become so if the low side of the dozer hits a solid rock or a stump.
- Coupling trailing equipment to a dozer is hazardous; be especially alert while this is being done. Whenever possible, couple equipment with the dozer stopped and the clutch, if so equipped, disengaged. Additionally, set the brake, and lower the blade.
- When towing a heavy load downgrade, keep the dozer in low gear. Coasting is dangerous. A coasting dozer with a towed load is likely to jackknife.
- Before dismounting a dozer and at the end of a workday, secure the dozer blade by lowering it to the ground. Lowering the blade prevents the dozer from rolling; most importantly, it eliminates the possibility of the blade falling on someone. Whenever it is necessary to work on the dozer with the blade up, especially when changing cutting edges, always securely block the blade to prevent it from falling accidentally.
- Wear required personal protective equipment such as steel-toed safety shoes and hard hats.

Test your Knowledge (Select the Correct Response)

7. **(True or False)** Before operating a dozer equipped with a ripper, it is a safe practice to learn the locations of any underground high-voltage electric lines or gas lines.

   A. True
   B. False

Summary

This chapter introduced you to the low and high track dozers. You were introduced to their major components, which include a track assembly and frame, as well as their controls for operating the blade and rear-mounted ripper. You were introduced to various blades used with dozers for specific applications. In addition, you were introduced to operations such as clearing brush and small to large trees. You were introduced to side-by-side and slot dozing, two techniques that increase production by reducing and preventing spillage around blade. Lastly, you were introduced to safety practices to adhere to when operating a dozer.

Review Questions (Select the Correct Response)

1. Dozers are usually rated by size and what other item?

   A. Engine size
   B. Power
   C. Track length
   D. Blade width

2. **(True or False)** Dozer drawbar pull is greatest in the highest transmission gear range.

   A. True
   B. False

3. What action should an operator perform when operating a dozer in water deep enough to reach the radiator?

   A. Tape off the air cleaner
   B. Tape off the exhaust stack
   C. Disconnect the fan belt
   D. Disconnect the batteries

4. What component of the dozer contacts the track pin bushings and propels the dozer along the track assembly?

   A. Drive sprocket teeth
   B. Front idler
   C. Carrier rollers
   D. Track rollers

5. What components, as they wear, will cause the track assembly to lengthen?

   A. Grouser shoes and pins
   B. Sprocket teeth and bushings
   C. Pins and bushings
   D. Recoil spring and front idler

6. What term is used to describe the most common dozer track shoe?

   A. Grouser
   B. Cleat
   C. Spikes
   D. Pads

7. What component keeps the track chain in alignment between the drive sprocket and the front idler?

   A. Track rollers
   B. Lift sheaves
   C. Support bearings
   D. Carrier rollers

8. What component serves as a guiding support for the track chain?

   A. Recoil spring
   B. Front idler
   C. Pitch arm
   D. Trunnion roller

9. **(True or False)** The track adjuster fitting should be lubricated every time daily operator's maintenance is performed.

   A. True
   B. False

10. Which of the following personnel are responsible for checking cutting edges and corner bits for wear?

    A. The Operations Officer
    B. The Dispatcher
    C. The Operator
    D. The Field Crew Mechanic

11. Most push arms are attached to what location on a blade?

    A. The top
    B. The center
    C. The front
    D. The bottom

12. A forward blade pitch adjustment is for dozing what type of material?

    A. Hard
    B. Sandy
    C. Salty
    D. Loose

13. Which of the following dozer attachments is used to break up compacted materials, uproot boulders and stumps, and rip up concrete slabs?

    A. Jackhammer
    B. Boulder buster
    C. Ripper
    D. Blade

14. On the Caterpillar D7G, how would an operator lower the right side of the blade?

A. Push the blade lift and tilt control forward.
B. Pull the blade lift and tilt control back.
C. Move the blade lift and tilt control left.
D. Move the blade lift and tilt control right.

15. On the Caterpillar D7G, how would an operator raise the ripper?

A. Move the ripper height control forward.
B. Move the ripper height control back.
C. Move the ripper height control left.
D. Move the ripper height control right.

16. Which of the following types of blades drift large volume loads efficiently over long distances?

A. Angle
B. “U"
C. Straight
D. Push

17. The winch line pull is what percentage greater than a straight dozer pull?

A. 10% to 20%
B. 30% to 40%
C. 50% to 100%
D. 60% to 100%

18. When rewinding the wire rope back onto the winch drum, the rigger’s hands should stay clear of the winch drum by at least how many feet?

A. 3
B. 6
C. 9
D. 12

19. Crossing ditches, ridges, rocks, or logs at an angle with a dozer produces which of the following results?

A. Slows the fall
B. Lessens the danger of upsetting the dozer
C. Reduces the jolt of the fall
D. All of the above

20. What size diameter tree is considered a large tree?

A. 4 inches
B. 6 inches
C. 8 inches
D. 10 inches

21. **(True or False)** Making contact or releasing pressure on a tree with a dozer should be performed quickly and smoothly to avoid any shock to the tree.

    A. True
    B. False

22. **(True or False)** Punctured radiators, broken hydraulic lines, and damaged exhaust stacks are common types of equipment damage that occurs when clearing brush and trees?

    A. True
    B. False

23. What action should an operator perform to increase the digging action of a straight-blade dozer working in hard ground?

    A. Tilt the top of the blade rearward
    B. Tilt the top of the blade forward
    C. Angle the blade to the left
    D. Angle the blade to the right

24. What is the maximum working distance for a medium-size dozer?

    A. 100 feet
    B. 200 feet
    C. 300 feet
    D. 400 feet

25. Side-by-side dozing is impractical for hauls of less than what distance?

    A. 50 feet
    B. 40 feet
    C. 30 feet
    D. 20 feet

26. Slot dozing can increase production up to what percentage?

    A. 50%
    B. 40%
    C. 30%
    D. 20%

27. A sidehill excavation can be started more easily if what type of cut is made first?

    A. Ditch
    B. Bench
    C. Slope
    D. Slot

28. What position should the dozer blade be in when backing away from the edge of soft fills?

    A. As high as possible
    B. As low as possible
    C. In the float position
    D. Angled

29. A blade on a straight–blade dozer must have what type of accessory before it can be used as a push dozer?

    A. A cutting edge
    B. A hard facing
    C. A reinforced block
    D. A rubber bumper

30. **(True or False)** An operator of a dozer should always wear a seat belt when dozing.

    A. True
    B. False

31. **(True or False)** When towing a heavy load downgrade, the dozer should be in the highest gear.

    A. True
    B. False

32. **(True or False)** When changing a blade's cutting edge, the blade must be securely blocked.

    A. True
    B. False

Terms Introduced in this Chapter

Drift	The process of pushing materials straight ahead in front of the dozer blade.
Drawbar	A fixed or hinged bar, extending to the rear of a tractor and used as a fastening for lines and towed machines or loads.
Draw horsepower	A tractor's flywheel horsepower minus friction and slippage losses in the drive mechanism and the tracks or tires.
Draw pull	The pull that a tractor can exert on a load attached to the drawbar. Depends on power, weight and traction
Felled	A term used in forestry to refer to a chopped or knocked down tree.
Ground pressure	The weight of a machine divided by the area in square inches of the ground directly supporting it.

Additional Resources and References

This chapter is intended to present thorough resources for task training. The following reference works are suggested for further study. This is optional material for continued education rather than for task training.

Apprentice Construction Equipment Operator, Volume 1 CDC 131, General Subjects and Contingency Responsibilities, Extension Course Institute, Gunter Air Force Base, Montgomery, AL, 1984.

Construction Equipment Operator, Volume 2, CDC 55151, “Earth Moving and Compaction,” Extension Course Institute, Gunter Air Force Base, Montgomery, AL, 1985.

Construction Mechanic 3 & 2, NAVEDTRA 10644-G1, Naval Education and Training Program Management Support Activity, Pensacola, FL, 1988.

Earthmoving Operations, FM 5-434, Headquarters Department of the Army, Washington, DC, 2000.

Equipment Utilization, U.S. Army Subcourse EN5468, U.S. Army Engineer School, Fort Belvoir, VA, 1988.

Heavy Equipment Operations: Level Three, 2nd ed., National Center for Construction Education and Research, Gainesville, FL and Pearson Education, Inc., Upper Saddle River, NJ, 2006.

Operation: D7G, D8K & D9H Track-Type Tractors, Caterpillar.

CSFE Nonresident Training Course – User Update

CSFE makes every effort to keep their manuals up-to-date and free of technical errors. We appreciate your help in this process. If you have an idea for improving this manual, or if you find an error, a typographical mistake, or an inaccuracy in CSFE manuals, please write or email us, using this form or a photocopy. Be sure to include the exact chapter number, topic, detailed description, and correction, if applicable. Your input will be brought to the attention of the Technical Review Committee. Thank you for your assistance.

Write: CSFE N7A
3502 Goodspeed St.
Port Hueneme, CA 93130

FAX: 805/982-5508

E-mail: CSFE_NRTC@navy.mil

Rate____ Course Name_____

Revision Date_____ Chapter Number____ Page Number(s)_____

Description

_____

_____

_____

(Optional) Correction

_____

_____

_____

(Optional) Your Name and Address

_____

_____

_____

Chapter 20

Rollers

Topics

To hear audio, click on the box. 

Overview

Rollers are compaction equipment used for mechanical compaction of earthwork materials as required by project specifications.

This chapter provides the information needed to successfully execute roller operations. It also describes the types of rollers used by Naval Construction Force (NCF) including description of major components and controls. In addition, this chapter explains rolling techniques and how to perform ***bituminous*** operations. Lastly, it lists safety practices.

Objectives

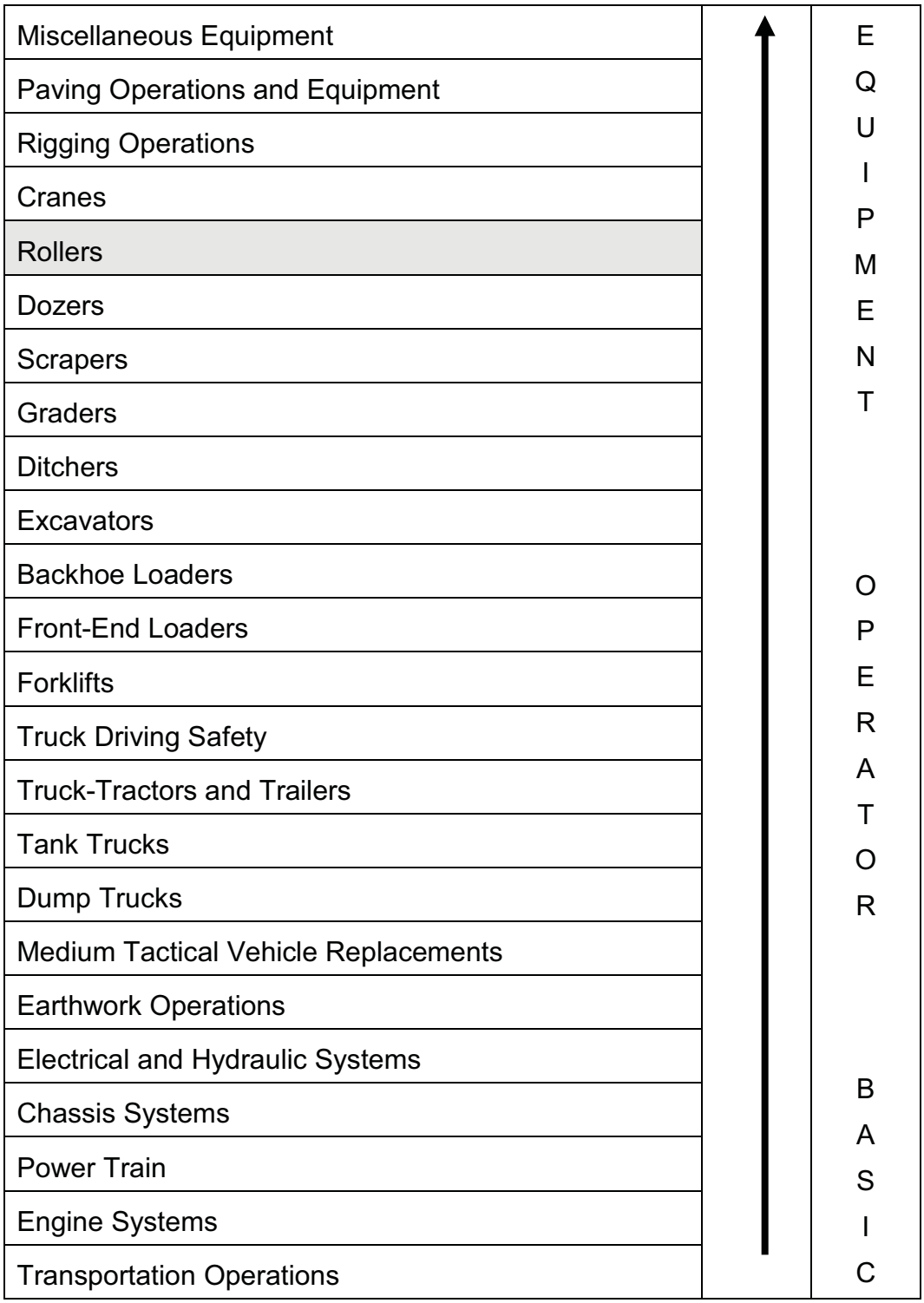
When you have completed this chapter, you will be able to do the following:

1. Understand the use of rollers.
2. Identify types of rollers used by NCF.
3. Identify the major components of rollers.
4. Identify the controls on the roller.
5. Understand how to perform rolling techniques.
6. Understand how to perform bituminous operations.
7. Understand roller safety.

Prerequisites

None

This course map shows all of the chapters in Equipment Operator Basic. The suggested training order begins at the bottom and proceeds up. Skill levels increase as you advance on the course map.



Features of this Manual

This manual has several features which make it easy to use online.

- Figure and table numbers in the text are italicized. The figure or table is either next to or below the text that refers to it.
- The first time a glossary term appears in the text, it is bold and italicized. When your cursor crosses over that word or phrase, a popup box displays with the appropriate definition.
- Audio and video clips are included in the text, with italicized instructions telling you where to click to activate it.
- Review questions that apply to a section are listed under the Test Your Knowledge banner at the end of the section. Select the answer you choose. If the answer is correct, you will be taken to the next section heading. If the answer is incorrect, you will be taken to the area in the chapter where the information is for review. When you have completed your review, select anywhere in that area to return to the review question. Try to answer the question again.
- Review questions are included at the end of this chapter. Select the answer you choose. If the answer is correct, you will be taken to the next question. If the answer is incorrect, you will be taken to the area in the chapter where the information is for review. When you have completed your review, select anywhere in that area to return to the review question. Try to answer the question again.

1.0.0 ROLLERS

Any time soil is disturbed it expands and becomes very loosely packed. During the construction of a fill or subgrade, this loose soil must be compacted into a solid mass. The process of compressing the loose soil into a solid mass is called compaction. If the soil is not properly compacted during construction, it will settle, causing roads, building foundations, or runways to collapse.

Soil may be compacted naturally (settled) by weather and time. If the soil is porous, settlement may be accelerated by soaking it and allowing it to dry. This process is slow and cannot be depended upon to produce the high densities required by project specification. Another method of compaction is chemical stabilization, which involves the application of one or more chemicals to a soil to achieve a desired change in its characteristics. Chemical stabilization normally requires mechanical compaction to supplement it.

1.1.0 Types of Roller Used By Naval Construction Force

To accomplish mechanical compaction, the NCF uses various compaction techniques and types of compaction equipment, such the vibratory roller, pneumatic-tired roller, and steel-wheeled roller.

1.1.1 Vibratory Roller

The vibratory roller, like the one shown in *Figure 20-1*, provides compactive force by a combination of weight and vibration of its front mounted steel compaction roll, commonly referred to as a drum. Those used for compaction are self-propelled and vary in weight from 7 to 17 tons.

Figure 20-1 – Vibratory roller.

Pneumatic-tired wheels provide propulsion for single-drum models. The drums on vibratory rollers vary from 3 to 5 feet in diameter and 4 to 8 feet in width.

The engine, providing power for propulsion, also powers the hydraulically driven vibrating unit. Vibrations are generated by a rotating eccentric weight inside the drum, the speed of which determines the frequency, or vibrations per minute, of the drum. The weight and distance from the shaft of the eccentric determine the amplitude (amount) of the impact force. Both the frequency and amplitude of vibrations are controlled independently of roller travel and engine speed.

The vibration frequency of rollers used for compaction is generally between 2,000 to 3,000 vibrations per minute (vpm), depending on the model and manufacturer. Some models provide only one or two specific frequency settings; while others may provide a full range of frequencies within certain limits; for instance, 1,800 to 2,400 vpm.

Vibratory rollers achieve compaction through a combination of three factors: weight, impact forces (roller vibration), and vibration response in the soil.

- Weight is the natural force in compaction of soils. Vibrating rollers amplify their ***static weight*** through vibration to increase ***dynamic weight***.
- The impact forces are those generated by vibration of the compaction drum. They are regulated by controlling the frequency and amplitude of the vibration. The amount of impact force required to obtain optimum density depends on the type of material being compacted. The impact forces also vary with the diameter of the drum and the width and the ratio of the roller static weight and dynamic (impact) force.
- The vibration response in the soil or material is the result of the way the forces are exerted upon it by the vibratory roller. As with other types of rollers, the material will compact easily or with difficulty depending on its moisture content, cohesion characteristic, particle shape and texture, and confinement, for example, sandy soil requires more vibration and less impact force (amplitude). However, a soil with higher clay content requires more amplitude than vibration because of the kneading action necessary to compact the clay. Vibratory rollers exert repetitive dynamic force on the material, rather than the static force used by other rollers.

The frequency and roller speed should be matched, so there will be at least 10 downward impacts per foot of travel of the roller. The speed of the roller increases for a given frequency of vibration, and the spacing of the impacts grows farther apart.

When using vibratory equipment, keep in mind that the energy imparted by the vibratory wheel must be absorbed in the material being compacted. Controlling the amplitude permits the operator to vary the force developed from the wheel and, therefore, the energy imparted to the material. A change in the ***lift*** thickness and material gradation content may require adjustment in the amplitudes being used.

NOTE

It is important that the roller vibrate only when it is moving. If vibration continues while the roller is standing still or changing direction, the vibrating drum will leave an indentation in the material at the stopping point.

Most modern rollers have automatic cutoffs for vibration when the roller stops moving.

1.1.2 Pneumatic-Tired Roller

The pneumatic-tired roller, like the one shown in *Figure 20-2*, is widely used for compaction of subgrades, bases, bituminous mixes, and many other types of material. It has thread-less rubber tires instead of steel tires or drums and generally features two tandem axles, with three or four tires on the front axle and four or five tires on the rear. The axles are aligned so the rear tires cover the spaces left between the tracks of the front tires. The tires are mounted in pairs that can oscillate, or singly with spring action, so tires can move down into soft spots that would be bridged by a steel drum. The rubber tires add to their downward pressure a ***kneading*** effect, as material is pressed toward spaces between the tires.

Figure 20-2 – Pneumatic-tired roller.

For greater ground contact pressure, pneumatic tired rollers can be ***ballasted*** with sand, water, steel or a combination of each. Sand and steel ballast can be added through large cover plates on the operation deck and water can be added through a fill port. Depending on size and type, the weight may vary from 10 to 35 tons. However, more important than gross weight is the weight per wheel for the material being compacted.

⚠ CAUTION ⚠

Pneumatic rollers ballasted with water are top heavy and very unstable when operating on uneven terrain.

Pneumatic-tired rollers may be equipped with 15-, 17-, 20-, or 24-inch tires. Air pressure in the tires may vary for different types of material, such as 50 to 60 psi to finish asphalt and 100 psi to compact a granular subbase. The tires must be inflated to nearly equal pressure with variation not exceeding 5 psi to apply uniform pressure during rolling.

Figure 20-3 shows the action of a pneumatic-tired the roller. Pneumatic-tired rollers are used because the individual wheels can exert a kneading action in small areas that wide, rigid steel drums tend to bridge.

Figure 20-3 – Action of a pneumatic-tired roller.

1.1.3 Steel-Wheeled Roller

The steel-wheeled roller, like the one shown in *Figure 20-4*, is used for compaction and finish operations on base coarse materials and asphalt. This roller produces a smooth, solid surface under favorable conditions, but may fail to compact areas narrower than the roll, and does not compact deeply in proportion to its weight. The steel- wheeled roller does not change shape to bring suitable support for itself. Rather, it sinks until enough bearing area has come in contact with the roll to support the roller weight.

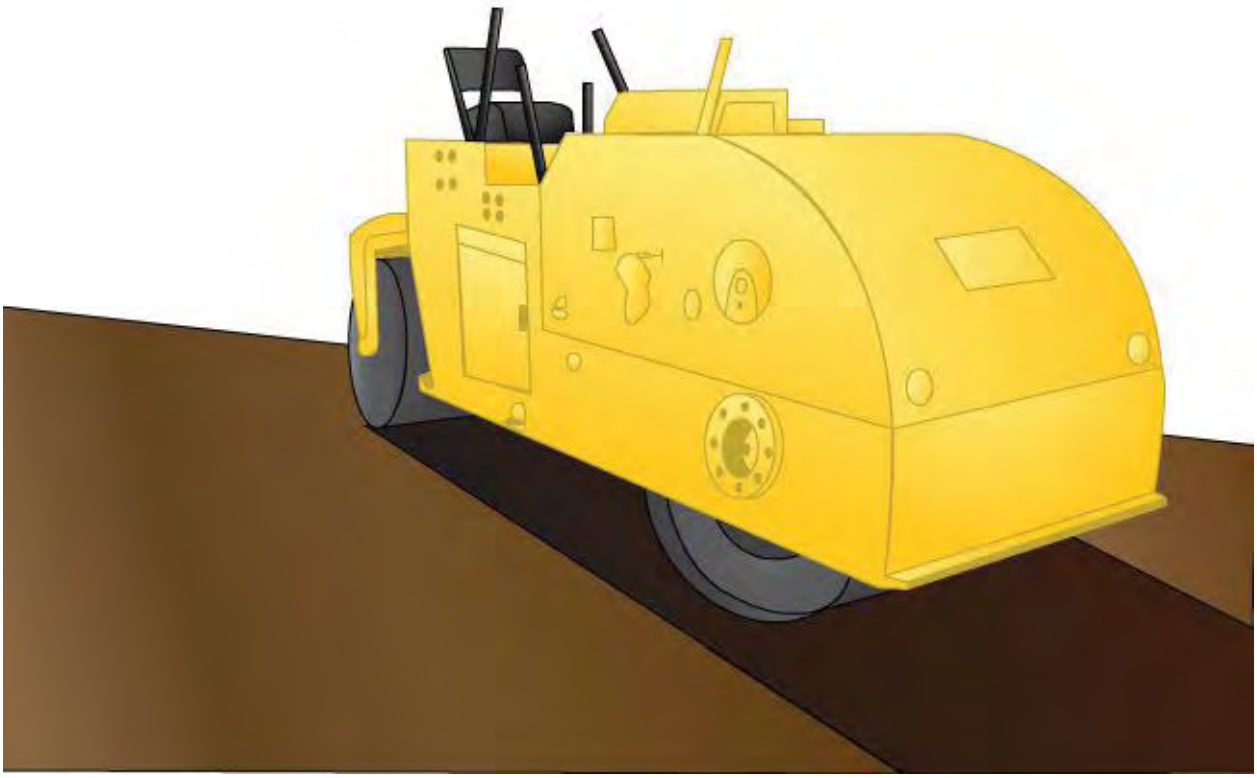


Figure 20-4 – Steel-wheeled roller.

The drive wheel is ahead of the tiller wheel in the direction of travel. The tiller wheel functions as a steering axle. As shown in *Figure 20-5*, the weight or the wheel causes a downward vertical force. The arrows, concentric with the steel wheel, represent the rotational force on the wheel. This force is transmitted to the base of the wheel, as the roller is propelled. This concentric force tends to move the material under the wheel, rather than to push it away. These forces result in a more direct vertical force than those of the forces under the tiller wheel.

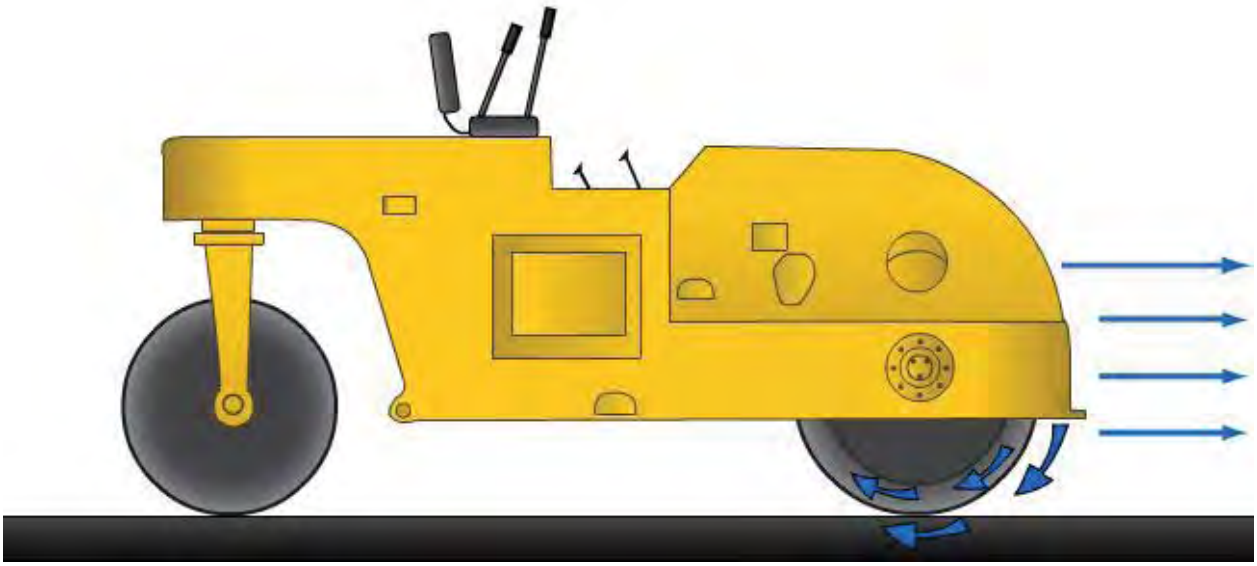


Figure 20-5 – Drive wheel rolling action.

Test your Knowledge (Select the Correct Response)

1. What type of roller is used for compaction of subgrades, bases, and bituminous mixes?

   A. The vibratory roller
   B. The pneumatic-tired roller
   C. The steel-wheeled roller
   D. The drum roller

2.0.0 MAJOR COMPONENTS

Despite multiple types, rollers have the same general major components: an operator's cab or console mounted on a self-propelling unit that functions as a rolling device. *Figure 20-6* shows the major components of a Caterpillar CS-563E vibratory roller.

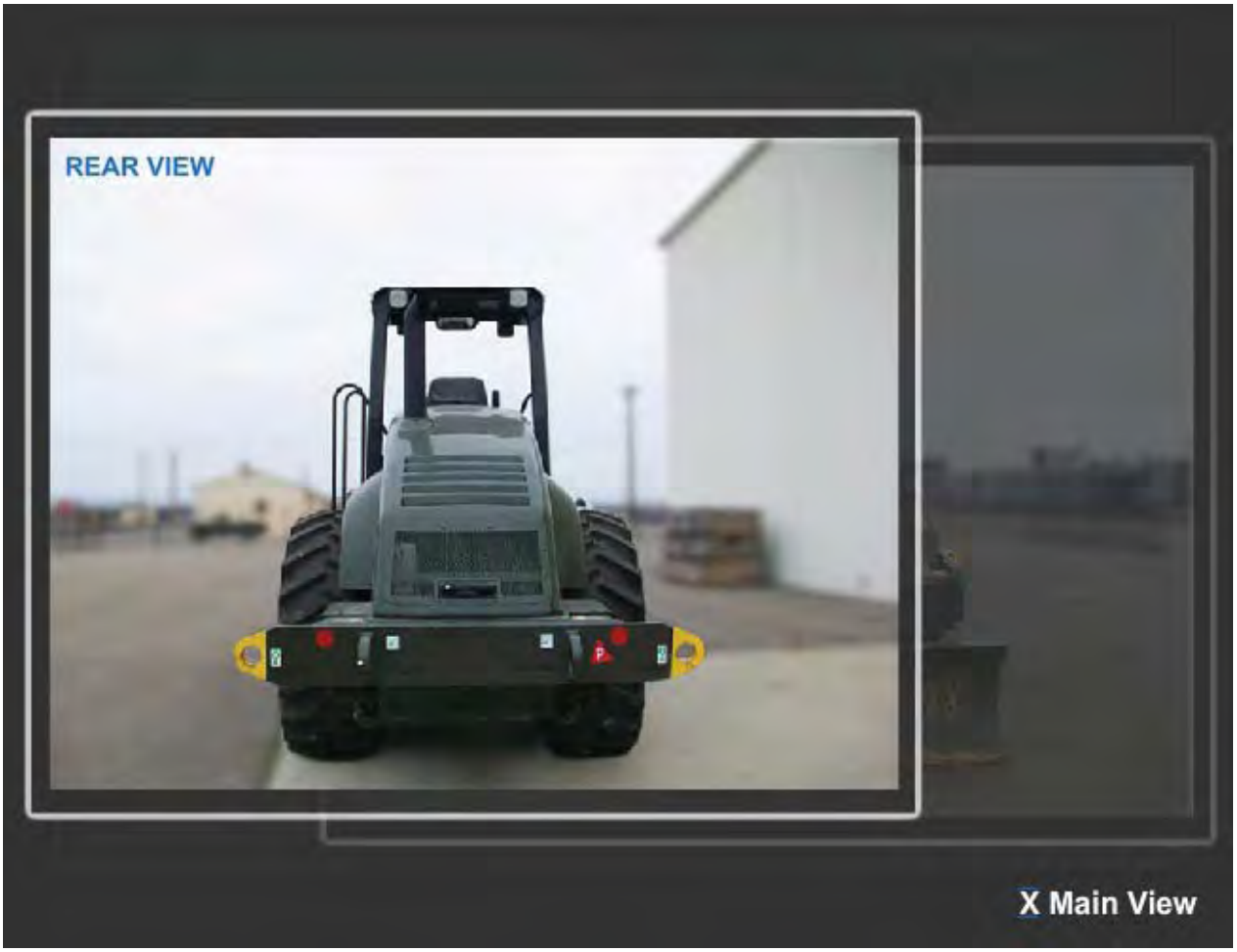


Figure 20-6 – Major components.

2.1.0 Operator's Console

The operator's console consists of an instrument panel and controls for vehicle movement, drum and attachment operation. It is common to see operator's consoles that are not fully enclosed; however frequently they are equipped rollover protective structures (ROPS).

2.2.0 Drums

Vibratory rollers used in the NCF are equipped with two interchangeable drums. One is known as the sheepsfoot and the other as the smooth drum.

2.2.1 Sheepsfoot Drum

The sheepsfoot drum, like the one shown earlier in *Figure 20-6*, is used for compacting heavy lifts of 6 to 12 inch thickness. As consecutive passes are made, the drum will start to walk out of the ground as the penetration of the sheepsfoot decreases. These rollers should only be used for initial compaction, because the footprints they leave will not allow excess water to drain. These rollers concentrate the static and dynamic weight on the relatively small contact area of the sheepsfoot. This force is exerted through the one row of feet in contact with the ground. With all the roller weight concentrated on this row of sheepsfoot, they exert more than 22,000 pounds of force.

2.2.2 Smooth Drum

In most heavy fills, a smooth drum roller like the one shown in *Figure 20-7* is used behind the sheepsfoot drum or sometimes a grader. With thinner lifts, a smooth drum is all the compaction equipment required. The smooth drum compacts lifts of 4 to 8 inches and seals the surface to allow the excess water to drain. Unlike the sheepsfoot drum, smooth drum rollers concentrate the full width of the drum. The total dynamic force is slightly less, because more of the drum is in contact with the ground.

Figure 20-7 – Smooth drum.

2.3.0 Blade

Very few attachments are used on or with rollers; however, some rollers like the Caterpillar CS-563E are designed to operate with a blade mounted in front of the drum.

Test your Knowledge (Select the Correct Response)

2. The sheepsfoot drum is used for compacting heavy lifts of what thickness range?

   A. 3 to 4 inches
   B. 6 to 12 inches
   C. 12 to 24 inches
   D. 24 to 36 inches

3.0.0 CONTROLS

Control configuration varies amongst roller makes and models. Some may be equipped with levers and others with joysticks to control vehicle movement and the operation of the drum and attachment. You are responsible for reading the operator's manual for specific information. For general understanding, *Figure 20-8* shows the controls on a Caterpillar CS-563E.

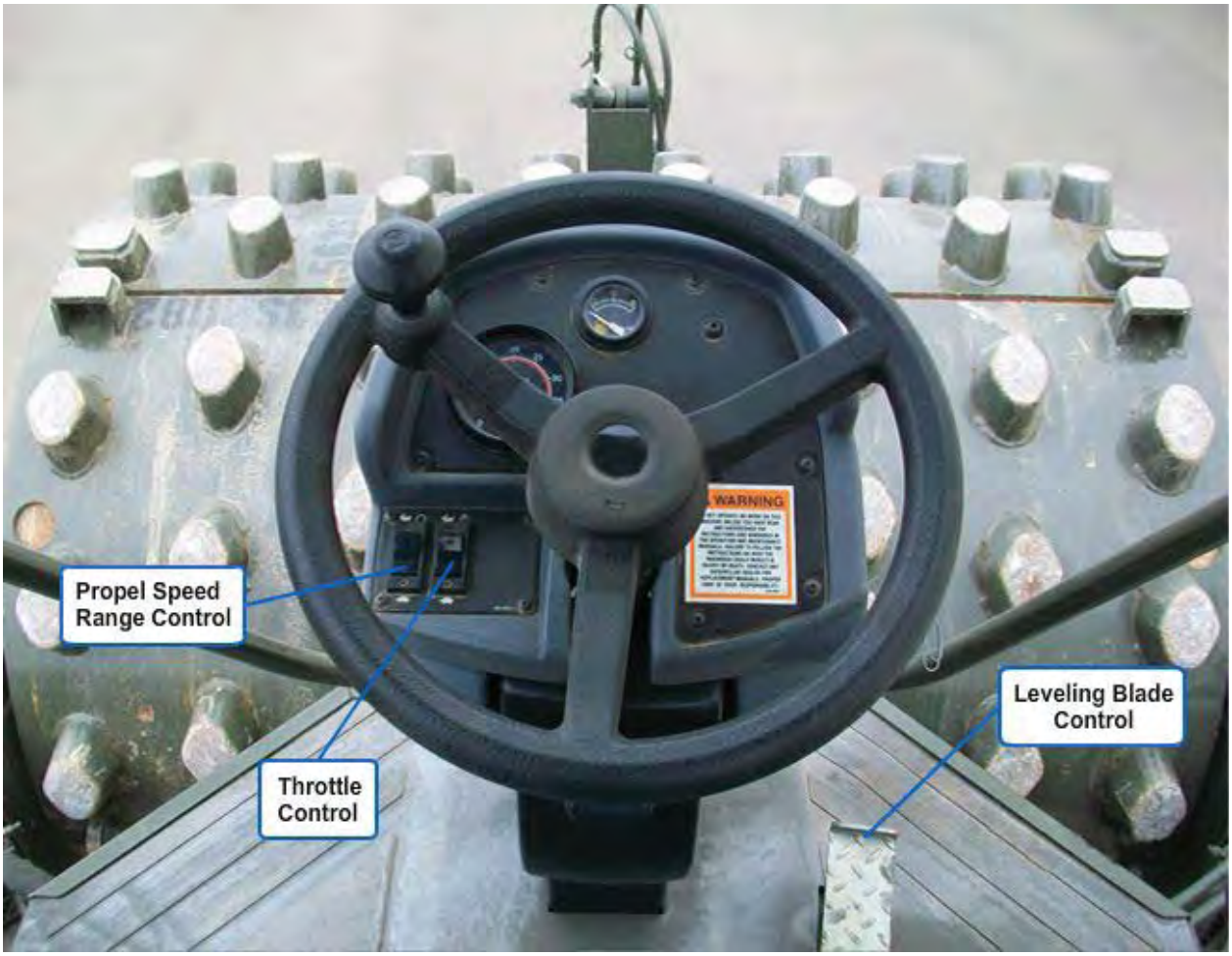


Figure 20-8 – Controls.

3.1.0 Steering Wheel

While some rollers have joysticks, most rollers have steering wheels to steer the machine left or right. Often these steering wheels are equipped have knobs that provide the operator greater control when steering with one hand.

3.2.0 Throttle Control

The Caterpillar CS-563E does not have a governor or throttle pedal; instead, it has a two-position switch to control engine speed.

- To increase engine speed, press the top half of the throttle control.
- To decrease engine speed, press the bottom half of the control.

3.3.0 Propel Speed Range Control

The propel speed range control allows the roller to operate in high or low range.

- To increase the overall speed of the roller, press the top half of the propel speed range control.
- To reduce the overall speed, press the bottom half of the control.

3.4.0 Propel Control

The propel control on the Caterpillar CS-563E functions in a similar manner to a transmission selector lever found on other construction equipment. It moves the machine forward or reverse.

- To move forward, push the propel control forward.
- To move in reverse, pull the control back.

Speed is determined by how far forward or back the lever is moved. In the center position, the roller will stop.

3.5.0 Vibratory Controls

The vibratory controls consist of an on/off switch, a vibratory amplitude control, and a variable vibration control knob.

3.5.1 Vibratory On/Off Control

The vibratory on/off control is a switch located on the top of the propel control. It controls the operation of the vibration system.

- To turn on the vibration system, press down on the vibratory on/off control.
- To turn the vibration system off, press down on the control once more.

3.5.2 Vibratory Amplitude Control

The vibratory amplitude control is three-position switch located on the right-hand side of the operator. It is used to select one of three settings: low amplitude, high amplitude, and off.

- To achieve low amplitude, press the bottom half of the vibratory amplitude control.
- To achieve high amplitude, press the top half of the control.
- To stop the vibration system, the control must be in the center position.

3.5.3 Variable Vibration Control Knob

The variable vibration control knob is used to vary the frequency of the drum vibration.

- To increase the drum vibration, rotate the variable vibration knob clockwise.
- To decrease the vibration, rotate the control knob counterclockwise.

3.6.0 Leveling Blade Control

Unlike other rollers that have joysticks or levers to control the height of the blade, the Caterpillar CS-563E has a foot pedal known as the leveling blade control. This control has four positions: completely and slightly forward, level, and back.

- To float the blade, completely press down on the toe end of the leveling blade control. The blade will remain in the float position until the operator physically presses down on the heel end of the pedal.
- To lower the blade, slightly press down on the toe end of the control.
- To raise the blade, press down on the heel end of the control.

- When the pedal is released from the lower or raise position, it will return to the level position, whereupon the movement of the blade will stop.

Test your Knowledge (Select the Correct Response)

3. **(True or False)** The Caterpillar CS-563E has a governor pedal to control engine speed.

   A. True
   B. False

4. On the Caterpillar CS-563E, the propel control functions similar to a _____.

   A. Throttle control
   B. Steering wheel
   C. Steering clutch
   D. Transmission selector lever

4.0.0 ROLLING TECHNIQUES

Roller techniques are basically the same with any type of roller. Some things you must consider are steering, changing direction, speed, and rolling sequence.

4.1.0 Steering

Steering sharply causes scuffing and damage to the surface; therefore, make turns slowly and gradually. You may have to back up several times to complete a turn.

4.2.0 Changing Direction and Speed

Start and stop gradually to avoid scuffing the surface. Begin stopping well ahead of the point where you want to stop. Engage the direction control slowly to avoid any wheel spin.

Rolling speed is 1 1/2 to 3 miles an hour. You must develop a rolling sequence to ensure the compaction is uniform throughout the fill.

4.3.0 Rolling Sequence

Overlapping is part of the rolling sequence. When rolling deep, loose fills, overlap at least half the drum width. Gradual extension of the rolled material into the unrolled area makes it possible for a greater concentration of weight on local ridges and high spots.

In rolling a graded area with a side slope, such as a crowned or banked road, work from the bottom to the top. The lower edges of the rolls have a tendency to push downhill, which can be best resisted by compacted material. In working uphill, the creep of soil away from the upper edge helps to preserve the slope.

A crowned road is rolled according to the pattern shown in *Figure 20-9*. Start at one edge and working to the center line. Then move diagonally to the opposite side and work to the center line from that side. Each rerolling is done in the same manner.

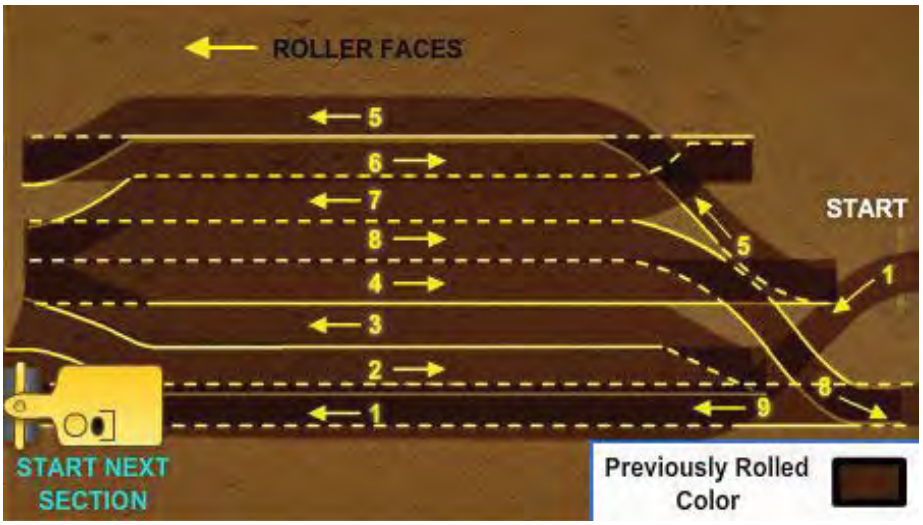


Figure 20-9 – Crowned road rolling sequence.

It is efficient to roll in sections as long as you can overlap the sections, as shown in *Figure 20-10.*

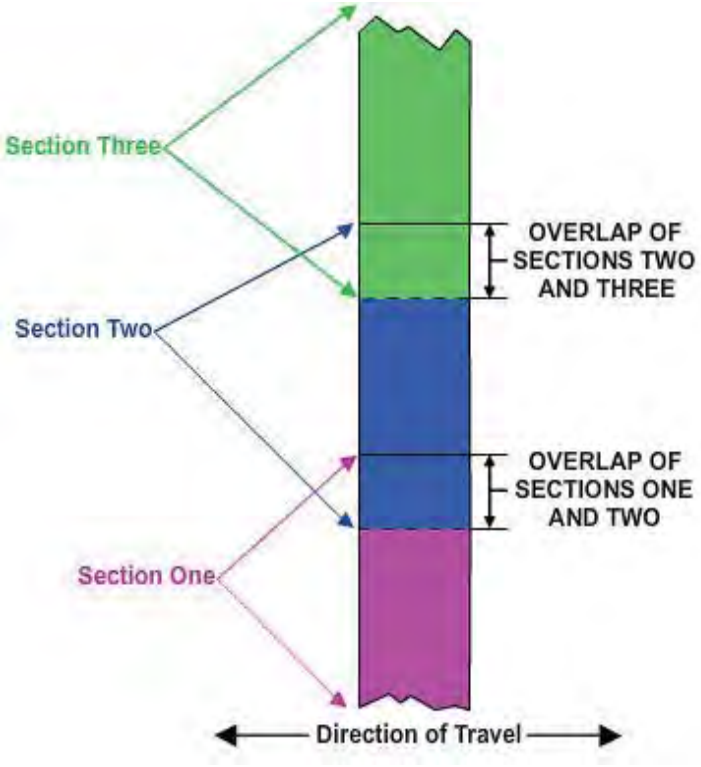


Figure 20-10 – Overlapping sections.

Roll banked or sloped elevated curves in the direction of travel, from the bottom (low side) to the top, as shown in *Figure 20-11*. Make the rolling transition from the road crown to the bank curve by a diagonal from the center of the crown to the low side of the bank. Make the rolling transition from bank to crown straight to the adjoining low side of the road crown.

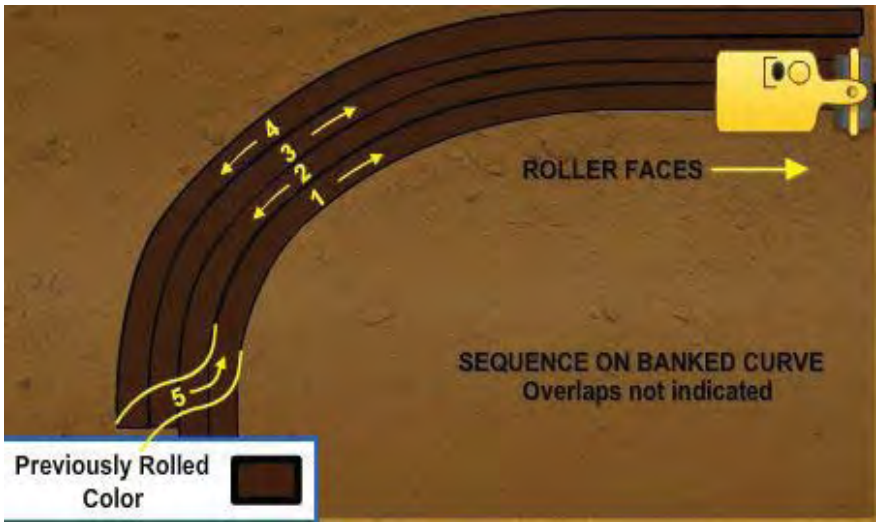


Figure 20-11 – Banked curved rolling sequence.

Continue rolling until you see no compaction advantage on the fill from successive passes. Too much water in the fill material may make compaction impossible. This may require scarifying and windrowing the fill to aerate the material. A rubbery or spongy rolling action of the fill that springs back into nearly its original condition when the rollers have passed may indicate trapped water below the surface. The rubbery or spongy area may require stabilization by other means, such as excavating the area and placement of riprap, soil cement, asphalt stabilization and so forth.

Test your Knowledge (Select the Correct Response)

5. When you are performing rolling operations, the roller should travel at what speed range?

   A. 1 1/2 to 3 mph
   B. 3 1/2 to 6 mph
   C. 6 1/2 to 9 mph
   D. 9 1/2 to 12 mph

5.0.0 BITUMINOUS OPERATIONS

Most of the compaction required in bituminous construction is achieved by the tamper on the asphalt paved. Additional compaction and final surface texture are achieved by applying the rollers in the proper sequence. The hot mix should be at its optimum temperature for rolling when the rollers start to operate on the mat being laid. This optimum temperature should range between 225°F to 285°F.

Rollers designed for bituminous operations are equipped with sprinklers that spray water on the smooth tires and drums. When rolling bituminous materials, the roller tires and drums must be moist with water to keep the bituminous material from sticking. When water is not enough to keep the bituminous material from sticking, a non-foaming detergent is added to the water until the water has a soapy feeling.

NOTE

Do not use a detergent that is designed to break down grease or oil, as this will break down the petroleum products used in the bituminous mix.

NOTE

Ensure roller tires and drums are free of debris such as sand, mud, dirt, and so forth, before rolling a hot bituminous mix.

⚠ CAUTION ⚠

Avoid prolonged skin contact with and inhalation of vapors from bituminous operations.

When you are rolling bituminous materials, the rollers should move at a slow, uniform speed with the drive wheels positioned toward the paver. The speed should not exceed 3 mph for steel-wheeled rollers or 5 mph for pneumatic-tired rollers. Asphalt rollers must be kept in good condition and should be capable of being reversed without backlash. Do not suddenly change the line of rolling or reverse the direction of rolling suddenly, thereby displacing the mix. Make any pronounced change in direction on stable material.

Roll hot bituminous mix in the following order:

1. Transverse joints
2. Longitudinal joints (when adjoining a previously placed lane)
3. Breakdown or initial rolling
4. Intermediate or second rolling
5. Finish rolling

As a guide, perform longitudinal joint and edge rolling directly behind the paver, breakdown rolling less than 200 feet behind the paver, intermediate rolling 200 feet or more behind the breakdown rolling, and finish rolling as soon as possible behind the breakdown rolling.

5.1.0 Transverse Joints

When a transverse joint is placed next to an adjoining lane, make the first pass with a steel-wheeled roller moving along the longitudinal joint for a short distance. Then straightedge the surface and make corrections if necessary. Then roll the joint transversely with all except 6 inches of the wheel width on the previously laid material (*Figure 20-12*). Repeat this operation with successive passes covering 6 to 8 inches of fresh material until the entire width of a roll is on the new mix.

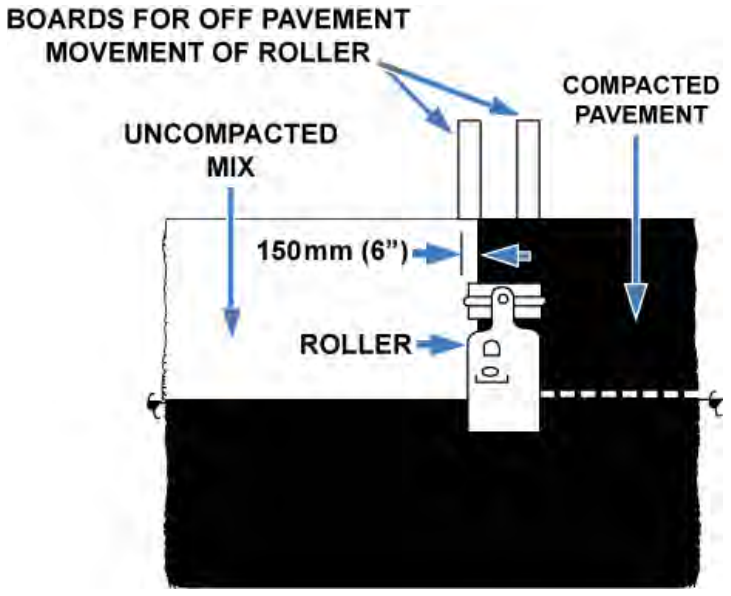


Figure 20-12 – Rolling a transverse joint.

During transverse rolling, place boards of proper thickness at the edge of the pavement to provide the roller a surface to drive on once it passes the edge of the hot bituminous mat. If you do not use boards, the transverse rolling must stop 6 to 8 inches short of the outside edge in order to prevent damage to the edge. The outside edge then must be rolled out during longitudinal rolling.

5.2.0 Longitudinal Joints

Roll longitudinal joints directly behind the paving operation. Only 4 to 6 inches of the roller width should ride on the newly placed mix (*Figure 20-13*). The rest of the roller should ride on the previously compacted side of the joint. With each subsequent pass, place more and more of the roller width on the mix until the entire width of the roller is on the newly placed mat. When rolling a longitudinal joint with a vibratory roller, the roller drum extends only 4 to 6 inches on the previously compacted lane with the rest of the drum width riding on the newly placed mat. The roller continues to roll along this line until a thoroughly compacted, neat joint is obtained.

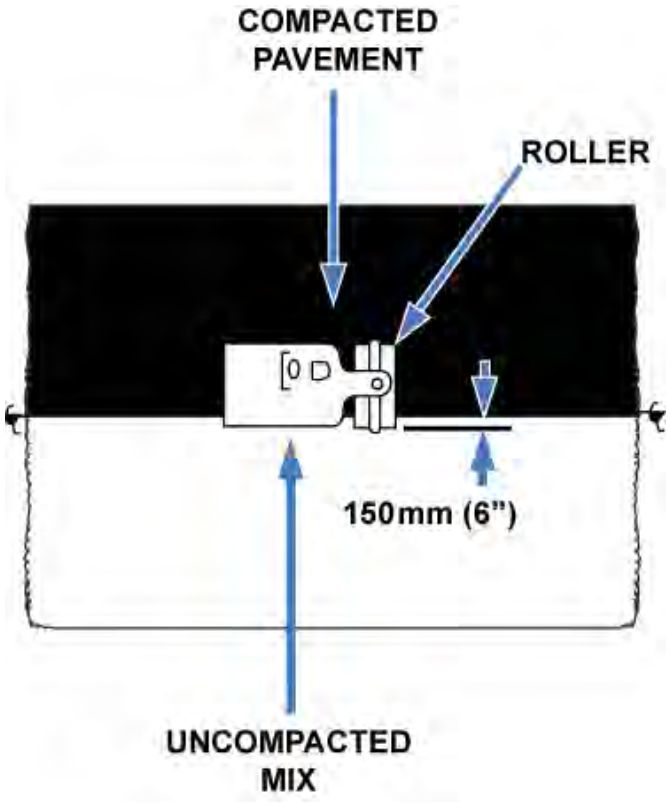


Figure 20-13 – Rolling a longitudinal joint.

Longitudinal joints can be categorized as hot or cold joints.

5.2.1 Hot Joint

A hot joint is a joint between two lanes of bituminous mix placed at approximately the same time by pavers working in echelon. This type of laydown produces the best longitudinal joint, because both lanes are at, or near, the same temperature when rolled. The material compacts into a single mass under the roller, resulting in little or no difference in density between the two lanes. When you are paving in echelon, the breakdown roller following the lead paver leaves a 3- to 6-inch unrolled edge that the second paver follows. The second paver and roller should stay as close as possible to the first paver to ensure uniform density across the joint. The roller following the second paver compacts the hot joint on its first pass (*Figure 20-14*).

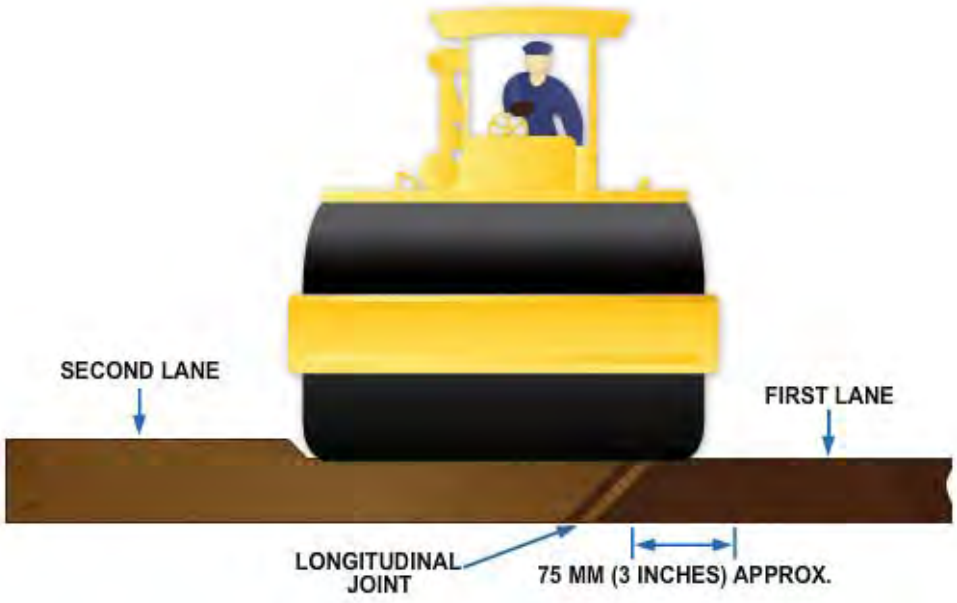


Figure 20-14 – Rolling a hot longitudinal joint.

5.2.2 Cold Joint

A cold joint is a joint between two lanes, one of which has cooled overnight or longer before the adjoining lane is placed. Because of the difference in temperature between the two lanes, there is a difference in density between the two sides of the joint. The longitudinal joint should be rolled directly behind the paver.

5.3.0 Breakdown Rolling

Breakdown rolling may be accomplished with static or vibratory steel-wheel rollers. Start breakdown rolling on the low side of the hot bituminous mat, which is usually the outside of the lane being paved, and progress toward the high side. The reason for this is that hot bituminous mixtures tend to migrate towards the low side of the mat under the action of the roller. If rolling is started on the high side, this migration is much more pronounced than if the rolling progresses from the low side. When adjoining lanes are placed, follow the same rolling procedure, but only after compaction of the longitudinal joint.

Use a rolling pattern that provides the most uniform coverage of the lane being paved. Rollers vary in width, and a single recommended pattern that applies to all rollers is impractical. For this reason, work out the best rolling pattern for each roller being used and follow it to obtain the most uniform compaction across the lane.

The rolling pattern includes not only the number of passes but also the location of the first pass, the sequence of succeeding passes, and the overlapping between passes. Rolling speed should not exceed 3 mph. In addition, avoid sharp turns and quick starts or stops.

For thin lifts (a lift of less than 2 inches compacted thickness), a recommended rolling pattern for static steel-tired rollers is shown in *Figure 20-15*. The rolling operation should start from the edge of the hot mat on the low side with the roller moving forward as close behind the paver as possible. The second movement of the roller should be reversed in the same path until the roller has reached previously compacted material. At this point align the roller for pass number three, again staying as close as possible

behind the paver. The fourth movement is a reversal of the third path and a repetition of the third operation. After the entire width of the hot mix has been rolled in this fashion, swing the roller back to the low side and repeat the process. With this pattern, on each forward pass the roller only needs to overlap the previous rolled area by 3 to 4 inches.

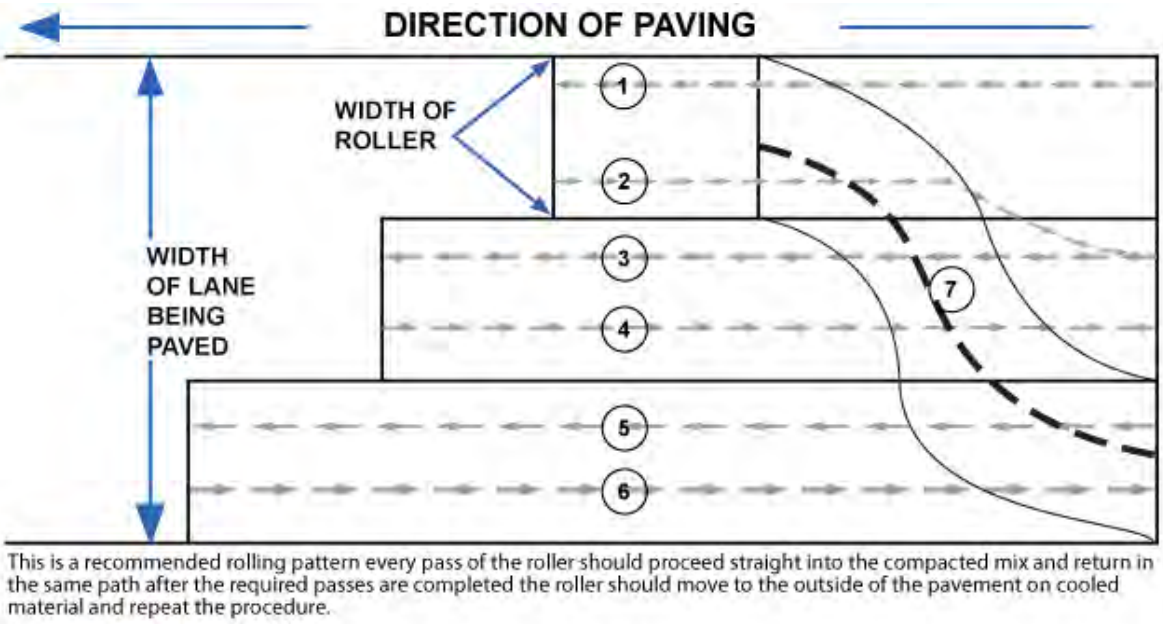


Figure 20-15 – Correct rolling pattern.

For thick lifts (a lift of 4 inches or more compacted thickness), start the rolling process 12 to 15 inches from the lower unsupported edge and progress towards the center portion of the hot mix. The uncompacted edge provides initial confinement during the first pass, thus minimizing lateral movement of the hot mix. After the central portion of the hot mix has been rolled and compacted, the compacted portion of the hot mix will support the roller and allow the edge to be compacted without lateral movement.

When using steel-wheeled rollers, the operation should always progress with the drive wheel forward in the direction of travel. This is especially important in breakdown rolling. A primary reason to do breakdown rolling with the drive wheel in the direction of travel is that this wheel applies a more direct vertical load than the tiller wheel *(Figure 20-16).*

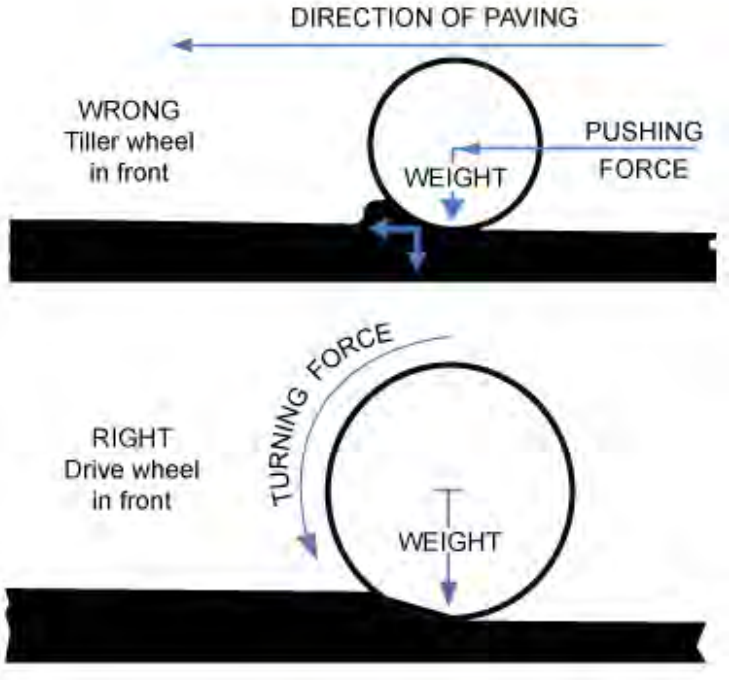


Figure 20-16 – Forces acting when tiller wheel or drive wheel is forward.

If the breakdown pass of the roller is made with the tiller wheel forward, the pushing force and the weight arc slightly ahead of the downward vertical force, causes material to push up in front of the wheel. The greater weight of the drive wheel produces the compaction, while the turning force tends to tuck the hot mix under the front of the wheel.

There are exceptions to rolling with the drive wheel forward. They usually occur when superelevations are being constructed or if the grade on which the asphalt mix is being placed is excessive. The exception occurs when, due to these high grades, the drive wheel of the roller begins to chatter on the hot mat, causing displacement of the hot mix resulting with a very rough surface. In these cases, the roller must be turned around to allow the tiller wheel to compact the material partially so the drive wheel can then proceed over it.

5.4.0 Intermediate Rolling

Intermediate rolling should closely follow breakdown rolling, while the asphalt mix is still well above the minimum temperature of 185 degrees at which densification can be achieved. Pneumatic-tired or vibratory rollers may be used for intermediate rolling. There are several advantages to using pneumatic-tired rollers. Not only do they provide a more uniform degree of compaction than steel-wheeled rollers, they also improve the seal near the surface by kneading the material closer together. In addition, they orient the aggregate particles for greatest stability, as high ground pressure truck tires do after using the asphalt surface for some time.

Tire contact pressures should be as high as possible without causing displacement of the mix that cannot he remedied in the final rolling. Pneumatic-tired rolling should be continuous after breakdown rolling until all of the hot mix has been thoroughly compacted. Make at least three coverages.

NOTE

Do not permit turning of pneumatic-tired rollers on the hot mix unless it does not cause undue displacement.

Vibratory rollers (of proper static weight, vibration frequency, and amplitude) are used to provide required densities with fewer coverages than static-weight tandem or pneumatic-tired rollers (or combinations of the two).

Regardless of the type of roller used, develop the rolling pattern in the same manner as for breakdown rolling. Continue this pattern until obtaining the desired compaction.

5.5.0 Finish Rolling

Finish rolling is done solely for the improvement of the surface. It should be accomplished with steel-wheel tandems, static-weight or vibratory, while the hot mat is still warm enough for removal of roller markers.

Test your Knowledge (Select the Correct Response)

6. What is the purpose of keeping roller tires and drums moist when rolling a hot mix?

   A. To help cool down the hot mix
   B. To keep the hot mix from sticking to the tires and drums
   C. To support the curing of the hot mix
   D. To clean the tires or drums of foreign materials

7. **(True or False)** Rolling hot bituminous mix is done in the following order: transverse joints, breakdown rolling, longitudinal joints, Intermediate, and finish rolling.

   A. True
   B. False

6.0.0 SAFETY

Many of the safety practices previously listed for graders, scrapers, and dozers also apply to roller operations. Additional safety practices are as follows:

- Never perform roller operations alone. Always have a safety person in the area of the rolling operation.
- Only operate the roller at speeds at which the machine can be kept under control at all times.
- Always wear a seat belt when rolling, as well as other required personal protective equipment, such as steel toe safety shoes and hard hats.
- Operate the roller from the sitting position, never from a standing position.
- Use the safety handrails when mounting or dismounting a roller. Do not grab the transmission control levers, as this might cause the roller to make a sudden movement.
- If the roller ignition starts in any transmission position besides neutral, this machine should be reported and repaired before further usage.
- Use caution and make sure the area is clear of personnel, tools, and vehicles when performing forward and reverse rolling operations.
- A roller is easier to overturn than most equipment. Rolling on a side slope should always be done at right angles or diagonally, rather than parallel to the slope.
- Steer carefully when rolling a shoulder to avoid capsizing into the ditch, and never bring a roller near the edge of a cut.
- Use extreme care when loading steel-wheeled rollers on tractor-trailers during periods of inclement weather. The wet deck of the trailer can cause a steel-wheel roller to slip during loading and unloading operations.

Test your Knowledge (Select the Correct Response)

8. **(True or False)** It is a safe practice to never perform roller operations alone.

   A. True
   B. False

Summary

This chapter introduced you to three types of rollers used by the NCF to achieve mechanical compaction: the vibratory, pneumatic-tired and steel-wheeled roller. You were also introduced to their major components and controls and to techniques for steering, changing direction and speed, and rolling as well as operations for rolling hot bituminous mix. Lastly, you were introduced to safety practices to adhere to when operating rollers.

Review Questions (Select the Correct Response)

1. What term is used to describe the process of compressing loose soil into a solid mass?

   A. Crushing
   B. Compaction
   C. Pulverizing
   D. Condensing

2. In roller operations, what does the acronym vpm mean?

   A. Vibration per mile
   B. Vibration pounding minutes
   C. Vibrations per minute
   D. Vibrations pulsate moment

3. Vibratory rollers achieve compaction through which of the following factors?

   A. Weight
   B. Impact forces
   C. Vibration response
   D. All of the above

4. The impact forces placed on the soil during compaction are generated by what action of the roller?

   A. The weight of the roller
   B. The vibration of the drum
   C. The kneading effort of the tires
   D. The speed of the roller

5. **(True or False)** If vibration continues while the roller is standing still or changing direction, the vibrating drum will leave an indentation in the material at the stopping point.

   A. True
   B. False

6. What type of compaction effort is generated by a pneumatic-tired roller?

   A. Vibration
   B. Pounding
   C. Kneading
   D. Shaking

7. The air pressure in the tires of a pneumatic-tired roller should be set at what psi to compact a granular subbase?

   A. 40 psi
   B. 60 psi
   C. 80 psi
   D. 100 psi

8. What type of roller may fail to compact areas narrower than the roll and does NOT compact deeply in proportion to the roller weight?

   A. The vibratory roller
   B. The pneumatic-tired roller
   C. The steel-wheel roller
   D. The sheepsfoot roller

9. **(True or False)** On the steel-wheeled roller, the drive wheel functions as a steering axle.

   A. True
   B. False

10. What type of roller is used for compaction and finish operations on base coarse materials and asphalt?

    A. The vibratory roller
    B. The pneumatic-tired roller
    C. The steel-wheel roller
    D. The sheepsfoot roller

11. A smooth drum roller is capable of compacting lifts of what thickness range?

    A. 4 to 8 inches
    B. 8 to 16 inches
    C. 16 to 32 inches
    D. 32 to 64 inches

12. On the Caterpillar CS-563E, how would an operator achieve low amplitude?

    A. Press the top half of the vibratory amplitude control
    B. Press the bottom half of the vibratory amplitude control
    C. Push the vibratory amplitude control forward
    D. Pull the vibratory amplitude control back

13. **(True or False)**To increase the drum vibration on the Caterpillar CS-563E, the variable vibration control knob is rotated counterclockwise.

    A. True
    B. False

14. How would an operator raise the blade on a Caterpillar CS-563E?

    A. Press down on the heel end of the leveling blade control
    B. Press down on the toe end of the leveling blade control
    C. Push the blade lever down
    D. Pull the blade lever back

15. When rolling a side slope, you should start the rolling process at what location?

    A. At the top of the slope
    B. At the middle of the slope
    C. At the bottom of the slope
    D. At a point 5 feet from either the top or bottom of the slope

16. What is the optimum temperature range for rolling a hot mix?

    A. 100° to 150°
    B. 150° to 185°
    C. 225° to 285°
    D. 300° to 325°

17. **(True or False)** When water is not enough to keep bituminous material from sticking to the tires or drums, you should use a detergent that is designed to break down grease or oil.

    A. True
    B. False

18. During hot mix construction, at what stage should longitudinal and edge rolling be performed?

    A. After breakdown rolling
    B. Directly behind the paver
    C. After intermediate rolling
    D. Before finish rolling

19. Breakdown rolling should start at what location on a hot bituminous mat?

    A. High side
    B. Center
    C. Low side
    D. Between the low and center

20. Which of the following factors must be considered when developing a rolling pattern?

    A. Location of first pass
    B. Sequence of succeeding passes
    C. Overlapping between passes
    D. All of the above

21. **(True or False)** Breakdown rolling with a steel-wheeled roller should be performed with the drive wheel positioned in the direction of travel.

    A. True
    B. False

22. Intermediate rolling should be performed before a hot mix reaches what minimum temperature?

    A. 100°
    B. 130°
    C. 165°
    D. 185°

23. **(True or False)** Rolling on a side slope should always be done at right angles or diagonally.

    A. True
    B. False

24. **(True or False)** When rolling a shoulder, it is a safe practice to steer carefully.

    A. True
    B. False

Terms Introduced in this Chapter

Ballasted	Given stability or weight to
Bituminous	Resembling or containing bitumen, a class of blade or dark-colored (solid semisolid, or viscous) cementitous substance, natural or manufactured, composted principally of high molecular weight hydrocarbon, or which asphalts, tars, pitches, and asphaltites are typical.
Dynamic weight	Combination of static weight and pressure in motion.
Kneading	To mix and work into a uniform mass, as by folding, pressing, and stretching.
Lift	A layer or course of paving material, applied to a base or a previous layer.
Static weight	Downward pressure due to overall heavy weight of the machine.

Additional Resources and References

This chapter is intended to present thorough resources for task training. The following reference works are suggested for further study. This is optional material for continued education rather than for task training.

Apprentice Construction Equipment Operator, Volume 1 CDC 131, General Subjects and Contingency Responsibilities, Extension Course Institute, Gunter Air Force Base, Montgomery, AL 1984.

Construction Equipment Operator, Volume 2, CDC 55151, “Earth Moving and Compaction,” Extension Course Institute, Gunter Air Force Base, Montgomery, AL, 1985.

Construction Mechanic 3 & 2, NAVEDTRA 10644-G1, Naval Education and Training Program Management Support Activity, Pensacola, FL, 1988.

Earthmoving Operations, FM 5-434, Headquarters Department of the Army, Washington, DC, 2000.

Equipment Utilization, U.S. Army Subcourse EN5468, U.S. Army Engineer School, Fort Belvoir, VA, 1988.

Heavy Equipment Operations: Level Three, 2nd ed., National Center for Construction Education and Research, Gainesville, FL and Pearson Education, Inc., Upper Saddle River, NJ, 2006.

Operation and Maintenance Manual CP-563E, CP-573E, CP-583E, CP-663E, CS-563E, CS-573E, CS-583E, CS-663E and CS-683E Vibratory Compactors, Caterpillar, 2003

Operations and Maintenance Manual: PS-150B and PS-200B Pneumatic Compactors, Caterpillar, 1998.

Principles of Construction of Hot-Mix Asphalt Pavement, The Asphalt Institute Manual, Series No. 22, Asphalt Institute Building, College Park, MD, 1983.

CSFE Nonresident Training Course – User Update

CSFE makes every effort to keep their manuals up-to-date and free of technical errors. We appreciate your help in this process. If you have an idea for improving this manual, or if you find an error, a typographical mistake, or an inaccuracy in CSFE manuals, please write or email us, using this form or a photocopy. Be sure to include the exact chapter number, topic, detailed description, and correction, if applicable. Your input will be brought to the attention of the Technical Review Committee. Thank you for your assistance.

Write: CSFE N7A
3502 Goodspeed St.
Port Hueneme, CA 93130

FAX: 805/982-5508

E-mail: CSFE_NRTC@navy.mil

Rate____ Course Name_____

Revision Date_____ Chapter Number____ Page Number(s)_____

Description

_____

_____

_____

(Optional) Correction

_____

_____

_____

(Optional) Your Name and Address

_____

_____

_____

Chapter 21

Cranes

Topics

To hear audio, click on the box. 

Overview

Cranes are essential to the support of Naval Construction Force (NCF) operations. Lifting heavy objects, loading and unloading construction materials, excavating earthwork materials, and driving and extracting piles are typical tasks accomplished with cranes and their attachments.

This chapter provides you the information needed to successfully execute such operations. It describes the types of cranes the NCF uses and includes description of major components, controls, and attachments. In addition, this chapter lists the responsibilities of crane crew members and explains how to perform crane operations.

Objectives

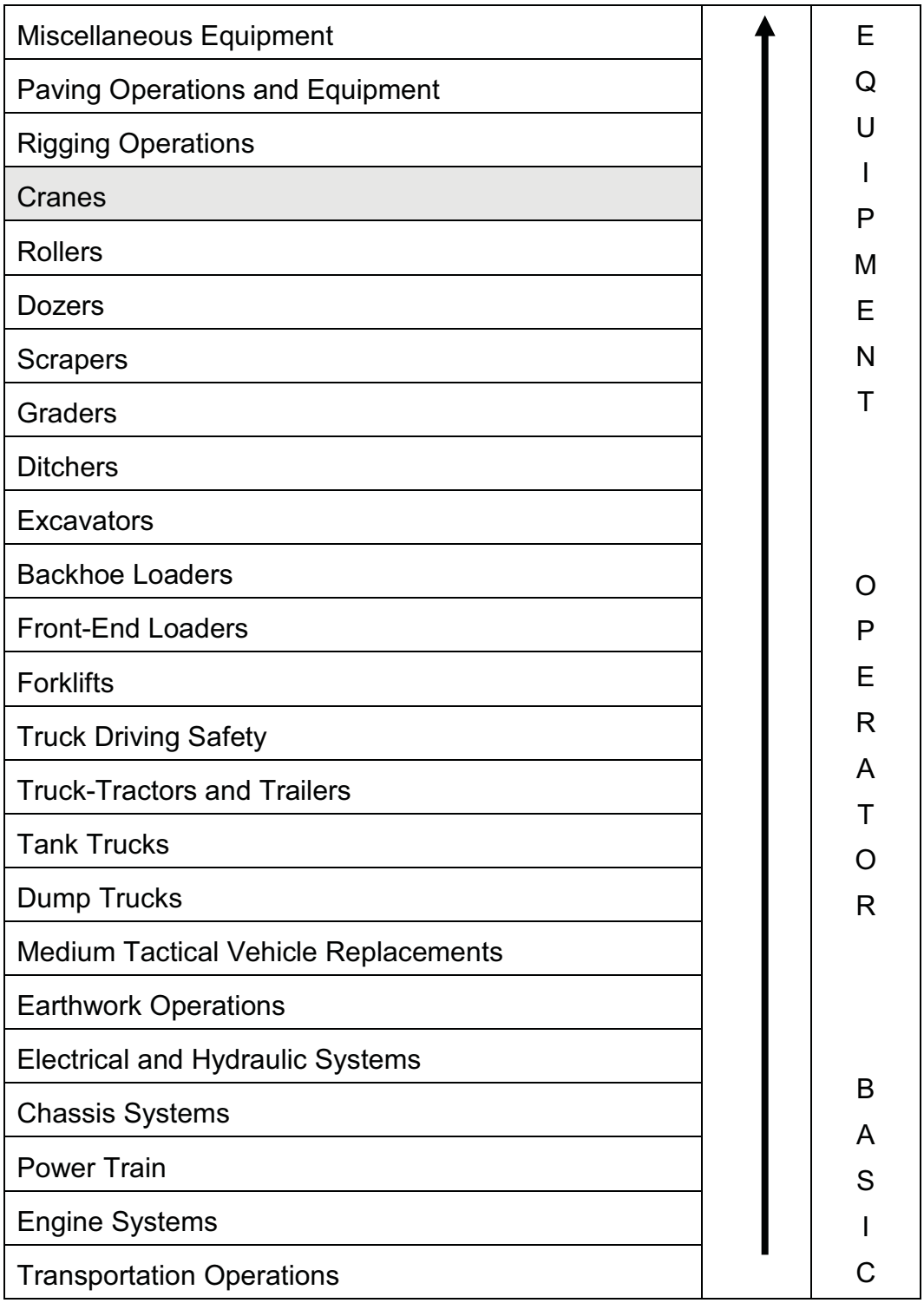
When you have completed this chapter, you will be able to do the following:

1. Understand the use of cranes.
2. Identify types of cranes used by NCF.
3. Identify the major components of cranes.
4. Identify the controls on the cranes.
5. Identify crane attachments and their use.
6. Identify the responsibilities of those on the crane crew.
7. Understand how to perform crane operations.

Prerequisites

None

This course map shows all of the chapters in Equipment Operator Basic. The suggested training order begins at the bottom and proceeds up. Skill levels increase as you advance on the course map.



Features of this Manual

This manual has several features which make it easy to use online.

- Figure and table numbers in the text are italicized. The figure or table is either next to or below the text that refers to it.
- The first time a glossary term appears in the text, it is bold and italicized. When your cursor crosses over that word or phrase, a popup box displays with the appropriate definition.
- Audio and video clips are included in the text, with italicized instructions telling you where to click to activate it.
- Review questions that apply to a section are listed under the Test Your Knowledge banner at the end of the section. Select the answer you choose. If the answer is correct, you will be taken to the next section heading. If the answer is incorrect, you will be taken to the area in the chapter where the information is for review. When you have completed your review, select anywhere in that area to return to the review question. Try to answer the question again.
- Review questions are included at the end of this chapter. Select the answer you choose. If the answer is correct, you will be taken to the next question. If the answer is incorrect, you will be taken to the area in the chapter where the information is for review. When you have completed your review, select anywhere in that area to return to the review question. Try to answer the question again.

1.0.0 CRANES

Cranes are classified as weight-handling equipment (WHE). They are primarily designed to perform weight-lifting and, with the proper attachment, excavating operations under varied conditions.

Cranes have many configurations to accomplish various construction operations and are typically identified by their carrier and type of boom. When an attachment is used with a crane, operators often refer to the crane by the name of the attachment.

Operating a crane can be exciting yet challenging. Proper operation of cranes and their attachments requires more knowledge and skill than does any other piece of construction equipment you will operate; therefore, Navy-wide programs have been established and resources have been published to ensure safe and efficient operations while optimizing equipment service life.

Programs like the WHE Program outlined in Naval Construction Force Equipment Management Instruction, COMFIRSTNCDINST 11200.2 and publications like *Management of Weight Handling Equipment*, NAVFAC P-307, encompass not only safety, but also operator training and testing, operating procedures including daily checks and operational cycling, and certifying requirements for cranes. 1st Naval Construction Division (1NCD) has established Ancillary Equipment Procedures (AEPs) for specific types of cranes and operations. Such procedures incorporate instructions provided by the original equipment manufacturer (OEM), 1NCD Crane Program, and NAVFAC P-307. 1NCD has also established standard operating procedures (SOPs) for general crane operations.

NOTE

This chapter will present information provided by NAVFAC P-307 (June 2006), COMFIRSTNCDINST 11200.2, and 1NCD Crane Program's website. Because the information may change over time, always refer to the most current publication or instruction prior to crane operations.

Test your Knowledge (Select the Correct Response)

1. Cranes are classified as what type of equipment?

   A. Material-handling
   B. Load-handling
   C. Weight-handling
   D. Cargo-handling