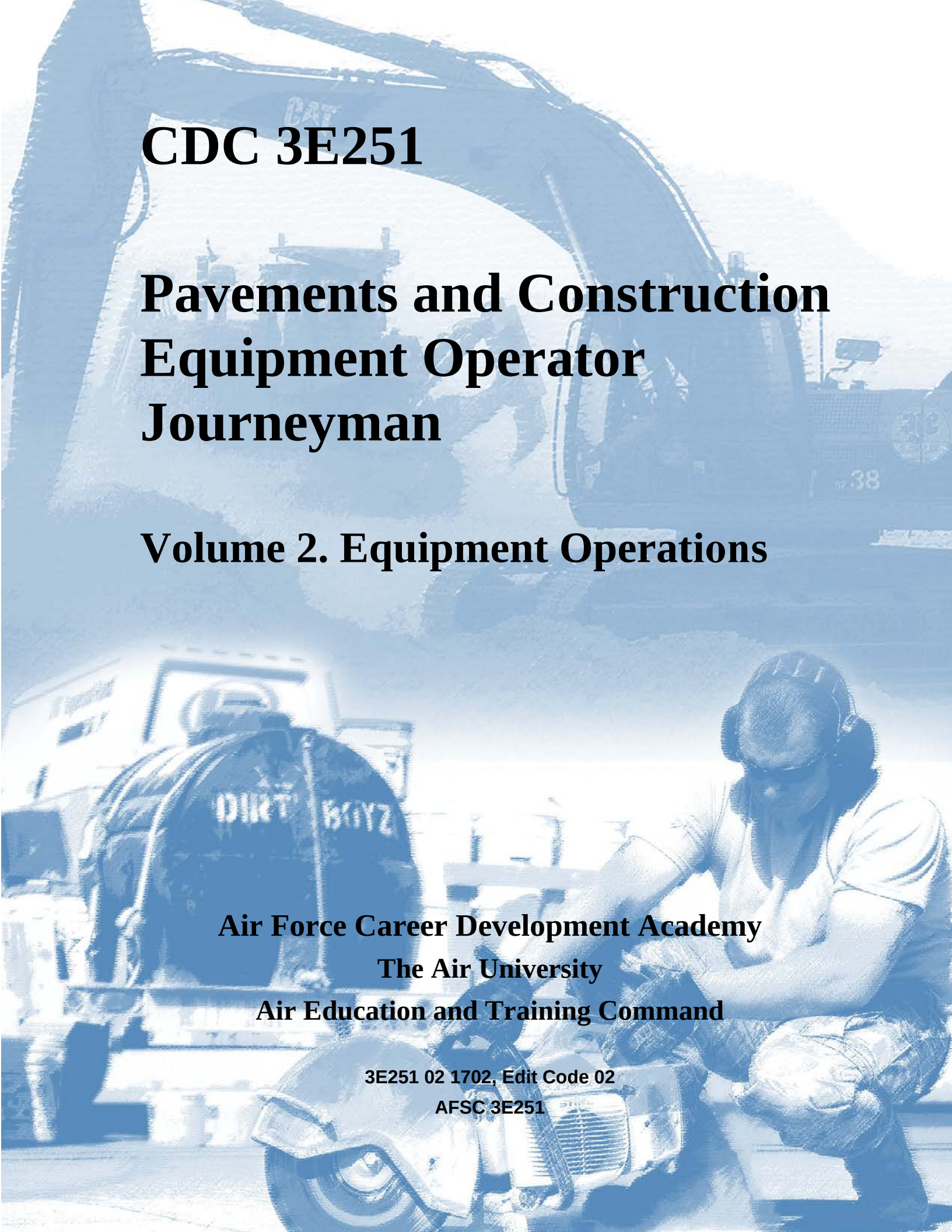

CDC 3E251

Pavements and Construction Equipment Operator Journeyman

Volume 2. Equipment Operations

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Material in this volume is reviewed annually for technical accuracy, adequacy, and currency. For SKT purposes the examinee should check the *Weighted Airman Promotion System Catalog* to determine the correct references to study.

This volume of CDC 3E251, *Pavements and Construction Equipment Operator Journeyman*, begins with earthmoving equipment such as dump trucks, loaders, dozers and graders. We will finish the first unit with a discussion about scrapers. The second unit involves equipment, which falls under the heading of "material handling," and will include tractor trailer combinations, forklifts and cranes. We are also going to fit in cargo loading and rigging as well. Unit three involves excavating and trenching machines and includes machines such as backhoes, excavators, and trenching machines. We will also be discussing what safety precautions we need to take when excavating, such as shoring, sloping and stepping excavations. Finally, unit four will be a discussion about all the support equipment you will use to complete the mission. Included in the unit are machines such as water trucks, compaction equipment, industrial tractors, sweepers, and snow removal equipment.

A glossary is included for your use.

Code numbers on figures are for preparing agency identification only.

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NOTE:

In this volume, the subject matter is divided into self-contained units. A unit menu begins each unit, identifying the lesson headings and numbers. After reading the unit menu page and unit introduction, study the section, answer the self-test questions, and compare your answers with those given at the end of the unit. Then complete the unit review exercises.

Page

Unit 1. Earthmoving Equipment

AS A PAVEMENT AND CONSTRUCTION equipment operator journeyman, you will be required to operate various types of construction equipment in order to accomplish your job. This includes earthmoving equipment such as dump trucks, loaders, graders, dozers, and scrapers.

Material handling equipment includes tractor trailer combinations, forklifts, and cranes. Excavating equipment includes such things as backhoes, excavators, and trenching machines. We will also discuss support equipment that aids us in accomplishing the civil engineering (CE) mission.

Some of the equipment is quite large and expensive and must be taken care of. The advantage of using this equipment is it makes your job considerably easier, and it also saves a tremendous amount of time. Without it, we could not complete the mission and would be quite ineffective. Let's begin the discussion with one of the most prevalent pieces of earthmoving equipment, the dump truck.

1–1. Material Handling Equipment

The hauling of materials is an important function on any Air Force (AF) base or installation. To handle all of this hauling, a variety of vehicles are needed. For example, dump trucks are used to haul dirt, sand, gravel, and similar materials. They can also be used to tow equipment and materials. In this section, we'll look at the dump truck operations that you will need to know to operate these vital pieces of equipment successfully.

201. Dump trucks

Dump trucks are used primarily to haul loose material such as dirt, sand, gravel, crushed rock, and asphalt to a construction site especially when the haul distance is great (fig. 1–1).

Although the operation of a dump truck is relatively simple, there are several important pieces of information you must know, and they are as follows:

- Dump truck equipment.
- Dump truck tailgate operations.
- Hauling procedures.
- Load spreading procedures.
- Towing equipment.

Figure 1–1. 10-ton dump truck.

Dump truck equipment

The difference between a truck that will dump and one that won't is the way it's equipped. A truck with a dump capability has the following:

- Dump box or body.
- Power takeoff (PTO).
- Hydraulic pump and cylinder.

As is the case with all of the heavy equipment you will operate, a preoperational inspection is required. To do this, start with the 360 degree walk-around referring to the AF Form 1800, Operator's Inspection Guide and Trouble Report, for a checklist of items to inspect. Look for exterior damage, leaks, low tire pressure etc. Once completed, move your inspection to the engine compartment, checking belts, fluids, leaks or cracks; if fluids are low, check the technical order (TO) or owner's manual for recommended fluid types. Before operating the dump truck, a vital preop step is to check the operation of the dump bed. Failure to check the dump beds operation prior to loading material may require it to be unloaded by hand.

The dump box is raised by engaging the PTO, which drives a hydraulic pump, which provides the necessary hydraulic fluid movement to raise or lower the bed. The cylinder is similar to a large hydraulic jack supported on frame members under the dump box.

To raise or lower the dump bed, use one of the two control knobs or levers mounted either on the dash or the cab floor. One control engages the PTO while the other controls the dump bed functions. Most bed control valves have three positions—raise, hold, and lower. To engage the PTO on a dump truck with an automatic transmission, the vehicle must be stopped. With the transmission lever in gear, engage the PTO.

NOTE: For a mechanically actuated PTO, if the gears don't mesh, let the truck creep ahead slowly while lightly pulling on the PTO control. After the PTO has engaged, you may move the transmission lever into neutral.

For electronically actuated PTOs, simply hit the switch. Make sure the transmission is in neutral with the brake on. Check your vehicle's manual for specifics regarding engagement of the PTO.

With the PTO engaged and the truck engine operating slightly above idle, move the hoist control valve in the cab to the "raise" position. To hold the dump box, move the hoist control valve to the hold position. To lower the box, move the control lever to the lower position. This procedure or function check should be performed before daily operations.

After the dump box has been lowered, disengage the PTO before traveling. If you travel with the PTO engaged, it could cause permanent damage to the internal gearbox, effectively putting the dump truck out of commission.

Dump truck tailgate operations

Dump truck operators have the primary responsibility for safely conducting operations and are required to be trained and certified on all procedures. The following requirements must be met when training for any tailgate operations:

- Personnel required: Three–one forklift/loader operator, one dump truck operator, and one safety spotter.
- Qualifications: Current license for each vehicle operator and AF Form 483, Certificate of Competency for tailgate removal/installation.
- Equipment: Fully operational forklift or loader with attachments rated for adequate weight to perform the job. Fully operational dump truck with spreader chains, safety pins, and hinges.
- Personnel protective equipment (PPE): Hard hat, gloves, hearing protection, and eye protection (if there is a need to punch out tailgate pins).

NOTE: When removing the tailgate in the field, only the dump truck operator and forklift operator are required for removing the tailgate if personnel constraints exist. The dump truck operator will act as the spotter in such a scenario.

The following tables list the removal and installation procedures that must be followed when using a front-end loader or forklift to remove (detach) or install the tailgate on a dump truck. These procedures apply to any size dump truck (e.g. five, 10-, 20-ton dump truck etc.) with a removable tailgate.

Tailgate Removal Procedures	
Step	**Description**
1	Perform operational check on each vehicle using AF Form 1800, Operator's Inspection Guide and Trouble Report.
2	The dump truck operator will conduct prebrief of safety/operational procedures listed in the lesson plan with the forklift/loader operator and safety spotter to include hand signal review.
3	The dump truck operator will remove the left and right tailgate spreader chains from the chain supports located on the truck before positioning the loader/forklift. This should be done from the ground. **NOTE:** This step is important to prevent binding of the tailgate that could lead to complications in the removal process.
4	The dump truck operator will ensure the tailgate-locking lever is in the CLOSED and LOCKED position.
5	The safety spotter will direct loader/forklift operator by use of hand signals to place forks approximately 12 inches below the top of the tailgate and a few inches away from the tailgate. **CAUTION:** The safety spotter will ensure personnel are clear of the tailgate area and forklift path.
6	The dump truck operator enters the truck bed using the truck ladder and pulls the retaining/cotter pins from the top pivot pins of the tailgate and taps out the hinge pins. Use a punch if necessary; NEVER insert fingers into the hinge.
7	The dump truck operator will push the tailgate at the top to free it from the top pivot points allowing the top of the tailgate to fall freely onto the forklift tines. **CAUTION:** The dump truck operator will move safely away from the tailgate after pushing it free of the pivot points.
8	The dump truck operator exits the truck bed using the truck ladder.
9	The safety spotter directs the forklift operator to lower the forks slowly until the tailgate becomes level with the bed floor of the truck.
CAUTION: The safety spotter must ensure all personnel are safely away from the tailgate during steps 10–13. When the bottom of the tailgate is hinged, and the top of the tailgate is resting on the forklift, there is a risk of the tailgate quickly slamming back to the dump truck when the forklift is moved. Never allow personnel to "hands-on" assist the loader/forklift. If problems are encountered, operations will stop, and the dump truck operator, safety spotter, and forklift operator will consult to develop a plan before resuming operations.	
10	The safety spotter directs the forklift operator to move towards the dump truck slowly to fully support the tailgate. **CAUTION:** Tailgate could rapidly slam back up to the truck, so the forks must stay level to the trucks floor and not angle up.
11	The dump truck operator pulls the tailgate release lever.
12	The forklift operator moves backward slowly and safely away from dump truck and places tailgate on dunnage prepositioned somewhere near the dump truck, but out of the way.
13	The dump truck operator reinstalls the tailgate pins into the removed tailgate hinge holes for safekeeping.

The procedures outlined here were developed to prevent injury to personnel. Follow these steps, and you can ensure you and your crew will complete the task with no incidents. Let's now look at the steps to install the dump truck tailgate.

Tailgate Installation Procedures	
Step	**Description**
1	Perform operational check on each vehicle using AF Form 1800.
2	The dump truck operator will conduct prebrief of safety/operational procedures listed in the lesson plan with forklift/loader operator and safety spotter to include hand signal review.
3	The dump truck operator will remove hinge pins from tailgate.
4	The safety spotter will direct loader/forklift operator to place tailgate on forks. The safety spotter will ensure the tailgate is positioned with the bottom of the tailgate away from the loader and that the forks do not protrude past the lower edge of the tailgate.
5	The dump truck operator opens the tailgate release lever and ensures it remains in the OPEN position.
CAUTION: The safety spotter must ensure all personnel are safely away from the tailgate during steps 6–12. When the bottom of the tailgate is hinged, and the top of the tailgate is resting on the forklift, there is a risk of the tailgate quickly slamming back to the dump truck when the forklift is moved. Never allow personnel to "hands-on" assist the loader/forklift. If problems are encountered, operations will stop. The dump truck operator, safety spotter, and forklift operator will then consult to develop a plan before resuming operations.	
6	The safety spotter directs the loader/forklift operator to move the tailgate to the dump truck.
7	The safety spotter directs the loader/forklift to keep forks level while moving to dump truck and carefully aligns/places lower pivot pins of the tailgate into the saddles of the dump truck bed.
8	The dump truck operator closes and locks the tailgate release lever.
9	The safety spotter directs loader/forklift operator back until only about 12–16 inches of the forks are under the tailgate. **CAUTION:** Ensure all personnel are safely away from tailgate.
10	The loader/forklift operator slowly raises the forks up to raise the tailgate.
11	The safety spotter directs the loader/forklift operator to stop, and then move slowly forward until the forks are again 12–16 inches from the top of the tailgate. **CAUTION:** Take care not to catch the tailgate's reinforcing structural members while raising the forks. Also, watch carefully as the tailgate could slam back against the truck.
12	Repeat steps 10 and 11 as necessary until the tailgate is in the full UPRIGHT position and CLOSED. **CAUTION:** DO NOT place hands or arms between the tailgate and the bed.
13	Once the tailgate is in position, the dump truck operator enters the bed, installs the upper pivot pins, and secures them with the retaining/cotter pins. **CAUTION:** Never insert fingers into the hinge area.
14	The loader/forklift operator backs away slowly from the dump truck.
15	The dump truck operator exits truck bed using the truck ladder.
16	The dump truck operator installs and adjusts the spreader chains.

The tailgate removal/installation operations are to be completed during daylight hours when possible with all personnel on the ground standing clear of the dump truck, tailgate, and forklift. Your trainer will issue you an AF Form 483, Certificate of Competency, after demonstrating these procedures successfully. This training is required for issue of a government driver's license for dump truck operations. The CE vehicle control noncommissioned officers (NCO) ensure compliance with these requirements.

Hauling procedures

Before loading your truck, make sure you know what your truck's capacity is to prevent overloading. Overloading can cause severe damage to the truck's suspension and drive train components. It also makes the truck harder to drive, maneuver, and stop, so never overload it. Before the truck is loaded, make sure the tailgate latch is closed. Leaving the tailgate open while driving could cause your load to spill, creating a hazard that you as the operator will be responsible for.

To dump dirt, gravel, or other like materials into a stockpile, back up to the pile but not onto the pile.

Backing into or onto a stockpile pushes the mud-flaps into the turning rear tires and could tear them off the dump truck. Before you dump the load, make sure the area is clear. Be especially mindful of overhead obstructions, such as power or telephone lines.

NOTE: When backing up, use a spotter to avoid an accident from backing into another vehicle or piece of equipment. Open the tailgate and dump the load.

To ensure the load is dumped completely, put the transmission in neutral and let your foot off the brake, allowing the truck to roll forward slightly as the material is dumped. After the dump box has been emptied, lower the bed slowly and completely before moving forward or backward. Doing so will prevent you from running into overhead obstructions such as power or telephone lines. Lowering the bed before moving also ensures you don't encounter a tipping situation due to the raised bed's higher center of gravity. Use a spotter if required.

Before hot mixed asphalt can be transported, an approved asphalt relief agent must be used to coat the dump truck's bed. DO NOT use diesel fuel to coat the inside of the bed because diesel fuel breaks down the asphalt and is extremely harmful to the environment. If you must haul hot mix asphalt a long distance, cover it with a tarpaulin to prevent rapid heat loss. Tie the tarpaulin down securely to keep it from fanning in the wind. The more the tarpaulin fans, the faster the asphalt will cool.

Load spreading procedures (spread dumping)

The tailgate adjusting chains on the back of the dump truck are used to regulate the amount the tailgate opens with the bed raised and the release lever opened (fig. 1–2). These chains can be adjusted so you can spread loose materials in layers. If you choose to do this, stop the truck where you want to start the spread, place the dump control levers in the proper position, raise the bed enough to break the material free, and trip the tailgate as you drive forward in low gear. As you drive forward, slowly raise the bed and watch the material as it comes out.

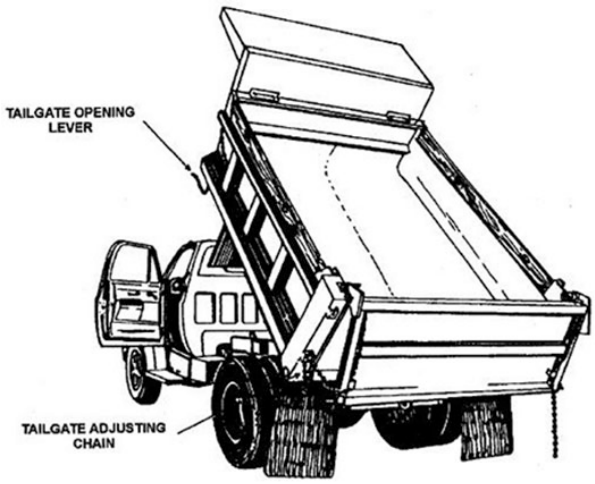


Figure 1–2. Rear view of five-ton dump truck.

NOTE: If the transmission is not in low gear, the bed will not raise. If you can't raise the bed, you will not be able to empty the entire load, and you won't get an even spread of material.

It should be spilling out in a uniform layer, not in piles. Slow and steady forward motion coupled with slow and steady upward bed movement, usually produces the best results. Usually, a 3–4 inch uniform layer of material is best for most projects. After you have dumped the desired amount, stop the dump truck, and lower the dump bed. This will prevent potential damage to the rear hinges and lift cylinder if you will be traveling over rough terrain.

Spread dumping takes a lot of practice, but if your chains are adjusted properly, and you don't go too fast, you can master the technique quickly.

Towing equipment

You will often have to tow equipment such as air compressors or an equipment trailer loaded with a compact track loader (CTL) to your job site. For this task, the dump truck is equipped with a pintle hook. The pintle hook is a jaw-like device that's opened by lifting the latch located at the top of the pintle hook, then pulling up on the upper jaw until it is in the fully open position. Use a spotter to back the dump truck until the lunette is positioned over the lower jaw of the pintle hook. The lunette is a round-shaped eyelet mounted on the front of the trailer or piece of equipment that's to be towed (fig. 1–3). After the truck is stopped, lower the lunette onto the lower jaw of the pintle hook.

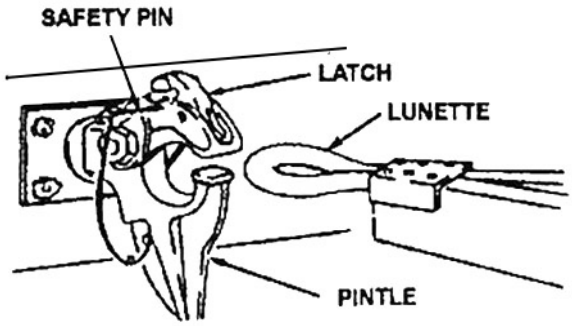


Figure 1–3. Pintle hook.

Close the upper jaw of the pintle hook and ensure the latch is engaged properly (you shouldn't be able to open the upper jaw). Insert the safety pin through the side of the upper jaw ensuring the pin goes through the upper jaw and safety latch. This pin prevents the pintle hook from coming open when the vehicle is transporting the piece of equipment.

For added safety, safety chains should then be attached to the dump truck from the piece of equipment being towed. Make sure the safety chain hooks have latches affixed so the chains don't inadvertently fall off the tow vehicle.

If this is all done correctly, the chances of accidental disconnection will be greatly reduced. After you have everything hooked up and secured, you're ready to start towing. Start out slowly and keep a watch not only on the equipment you're towing but also on other drivers. Never exceed the allowable towing speed of the equipment you are hauling. Check the maximum speed allowed for each type of equipment being towed and never exceed it. If you need to stop in a hurry, the equipment you're towing and anything you're hauling in the bed will greatly increase your stopping distance. For this reason you need to anticipate not only yours, but everybody else's moves, and keep a safe distance behind vehicles in front of you.

202. Front-end loaders

The second piece of earthmoving equipment we are going to discuss is the front-end loader, or simply "loader." The loader is versatile and extremely important to our mission. Without the loader, we could not complete many of our projects.

A front-end loader is a wheeled vehicle with a hydraulically operated, front-mounted bucket. We use it for excavating, loading, or lifting objects. The front-end loader is a self-contained unit that is normally mounted on rubber tires or tracks (track loader). It is one of the most versatile and capable pieces of equipment used by CE personnel. Since you are more apt to operate wheel-mounted, front-end loaders than track-mounted units, we concentrate our efforts on the wheel-mounted type.

Because we can mount different types of attachments on a front-end loader, such as a bucket, boom, forklift, or blade, it is a very versatile machine. The front-end loader can be equipped to operate as a loader, a dozer, a scraper, a clamshell, and a forklift. Its value can be increased even more with a quick and simple method of changing these attachments. Quick couplers allow for quick attachment changes when the need arises. This allows for the maximum use of both manpower and equipment, giving you the flexibility to perform a multitude of jobs with minimal downtime during attachment changes.

A front-end loader can support itself by stripping, leveling, and cleaning its own work area. Because of its mobility, it can travel from one job site to another on a base without the assistance of another piece of equipment. Its versatility is further enhanced by its ability to operate over rough terrain. You can see why it's a very important piece of equipment in the CE equipment inventory.

Preoperational checks

To ensure that a loader is ready for any job, you must complete a preinspection before placing it into service. Using the AF Form 1800, Operator's Inspection Guide and Trouble Report, inspect the equipment for serviceability. Preoperational checks are those checks specified by the manufacturer prior to operating any equipment. When performing a preoperational check, always start with a 360-degree walk-around of the loader.

Using your inspection form, look for items such as low tire pressure, minimal hydraulic fluid levels, and hydraulic cylinders and hoses that might be damaged or leaking. Annotate any discrepancies on the AF Form 1800, and then, notify your supervisor as soon as possible.

Now move your inspection to the bucket area and look for loose teeth, blade wear, and loose or missing bolts. On buckets without teeth, check the wear of the cutting edges and end bits. Cutting edges and end bits are usually bolted or welded onto the bucket, and their only purpose is to wear out so the bucket doesn't. If they are worn to a point where the bucket may become damaged, they must be replaced immediately. Never let the cutting edges and end bits wear down that far. It is far easier to replace wear items than it is to rebuild or replace an entire bucket. Check the cutting edges as you may be able to turn them around (bolts are centered on the cutting edge) and not have to replace them. Replace the teeth if damaged or badly worn; the operator is responsible for their replacement. (See the technical reference or maintenance manual for replacement).

As you move on with the inspection, check other items such as engine oil, coolant, and transmission fluid levels. As the operator, you are required to fill low fluids such as engine oil and coolant. For transmission fluids, check with your supervisor to see if the shop or the maintenance section adds this type of fluid. Always look at the TO or owner's manual for the correct type of replacement fluid.

During operation, listen for abnormal sounds that might indicate loose parts or other damage. For instance, squeaking and scraping noises coming from the bucket and lift arm assembly indicates poor lubrication which should be addressed immediately. Poor lubrication leads to failure. Always check drive belts for wear, tension, and alignment. Loose belts will emit a specific sound which is a good indication that action needs to be taken. After you complete the preinspection, you can move on to loader function controls checks.

Functions and controls of front-end loaders

Loaders come in a variety of sizes and capacities, and they can have buckets as large as boxcars. AF front-end loaders generally fall into the one and one-half to four-cubic yard capacity bucket range.

They are usually diesel powered and have a power-shift transmission with up to six speed ratios, forward and reverse. On wheel-mounted models, the frame is hinged or "articulated" midway between the front and rear axles. A hydraulic system drives the attachments and provides the power to steer.

Functions

We show a typical front-end loader in figure 1–4. Some front-end loaders are equipped with a general-purpose bucket, which may be used to scoop and load loose material into a truck or to dig earth out of a bank. They can also be used to dig down; however, they are not as efficient at this as other pieces of equipment.

Figure 1–4. Front-end loader.

This heavy-duty and all-welded steel bucket has replaceable cutting edges and bolt-on teeth. It has the strength to perform excavation of small- to medium-type work. When equipped with a multipurpose (4-in–1) bucket, the loader can perform scoop-shovel, dozer, scraper, and clamshell functions. Another major attachment for the front-end loader is the boom and straight blade, which we will discuss later.

Additionally, the loader can be equipped with a forklift attachment which will be discussed in greater detail in the material handling unit within this volume.

Bucket controls

Bucket controls vary with the type of machine, but are normally located on the right side of the operator within easy reach. They normally consist of three levers: bucket control, lift control, and the clam control for the 4-in–1 bucket.

Bucket-control lever

The bucket-control lever is normally located on the extreme left in a set of three and is used to roll the bucket forward and backward. When you pull the lever back towards you, the bucket rolls backward, and when you push the lever forward, the bucket tilts forward.

Lift-control lever

The lift-control lever is normally located in the center of a set of three and is used to raise and lower the bucket. When you pull the lever back towards you, the bucket raises, and when you push the lever forward, the bucket lowers. In some models, there is a detent which holds the lever in the RAISE position, and the bucket will keep rising until it reaches the top of its range of movement. Simply “pop” the lever out of the detent, and it will stop rising. Conversely, if you push the lever all the way forward, the bucket goes into the FLOAT position (a forward detent). Float simply means there is no hydraulic pressure forced on the bucket. It will literally float over the ground. This position is good for back-dragging an area where you don’t want down pressure or when using the clamshell to load material.

Clam-control lever

The clam-control lever is normally located on the extreme right in a set of three and is used for opening and closing the clamshell on the 4-in–1 bucket. When you pull back on the lever, the clamshell closes. When you push the lever forward, the clamshell opens. This is common for most models; however, it is always good practice to become familiar with the machine you are operating.

Joystick

Newer loader models, two levers replaced by a single joystick, which controls the bucket (rolls it forward and back by moving the joystick left or right) and the lift control (pulling back on the stick raises the bucket, or moving it forward lowers the bucket). Additionally, there is normally a small auxiliary control lever placed near the main joystick to actuate the 4-in–1 bucket.

Locking mechanism

Loaders equipped with a quick-release mounting system have a lever or electrical switch to actuate the locking pins holding the attachment to the loader frame. The mounting system makes changing between attachments much easier. The actuating switch or lever is usually mounted on the dash or to the operator’s right side on the control panel.

Transmission controls

Transmission controls are usually located on the left side of the control panel or situated on the steering column. Normally, there are two levers that govern the transmission, the direction control and range-control levers. Column-mounted transmission controls have both directions (forward and reverse) and range (gears). There is also a clutch cutout that you use to disengage the transmission temporarily.

Direction-control lever

You use the direction-control lever to control the direction of the machine. The lever has three positions: F (forward), N (neutral), and R (reverse). Put the lever in the following:

- R position to move the loader backward.
- F position to move the loader forward.
- N position to start the loader and when the machine is idling.

Range-control lever or indicator

Like a manual automobile transmission, the range control lever has several positions depending on the work you are doing. In older models, there may only be three speeds; position one is the lowest and three is the highest. Normally, you use positions one and two when you are performing loading and excavating work. Use position three when moving the loader to and from the work site.

Newer models of loaders have many forward gears to accommodate differing situations. You can literally tailor the gear to the work you are doing. Additionally, some newer transmissions shift automatically like a transmission in your personal vehicle. Get familiar with the piece of equipment you are operating. If you don’t know how a specific vehicle operates, you will be inefficient, slow, and even dangerous.

Clutch cutout

A clutch cutout system is built into the transmission system. The clutch cutout system provides you with a convenient means of temporarily disengaging the transmission when the brake is depressed. With this system, you are allowed to make full use of engine power while operating the front-end loader.

To engage the clutch cutout on older models, depress the left brake pedal. This temporarily disengages the transmission. When you let up on the pedal, the transmission is reengaged. Only the left brake pedal controls the clutch cutout; the right brake pedal has no effect on the system as it only applies breaking force. On newer models, it is entirely electronic, and as such, there is no need for a second brake pedal. Again, get acquainted with how your loader operates before you try and work with it.

Operating a front-end loader

There are many factors to consider when planning for the best use of a front-end loader. One of these is the volume of material you must move. A front-end loader is great for soft to medium material, such as that found in stockpiles, but when the material is medium to hard; the front-end loader loses much of its efficiency. The loader works better on flat, smooth-surfaced areas with the proper amount of space to maneuver. If there are poor ground conditions and lack of space to operate efficiently, some other pieces of equipment may be more effective. Here are some other factors to consider:

- Height of material to be placed or dumped.
- Extent of prior loosening of the material.
- Weight and volume of the material.
- Slope of the operating area.
- Climatic conditions.
- Skill of the operator.
- Management factors.

It is impossible for you to just read about and become an expert on the front-end loader. You need on-the-job training with experienced trainers to operate the loader correctly.

When there are no trucks to be loaded, you can improve your operating techniques by leveling the loading area. When your next truck arrives, this makes loading smoother and faster. Also, use this time between truck-loads to practice your skills, such as using the clamshell, back dragging, and loosening the material to be loaded.

Typical uses of the front-end loader that mainly concern you include: loading, backfilling, leveling, stockpiling, and plowing with the blade attachment and lifting material using the boom.

Loading operations

There are two ways you can pick up materials with the front-end loader: the scoop method and the clamshell method. You can use these methods when loading almost any type of material.

Scoop method

The scoop method is more often used as it is more effective and yields more material in the bucket. Follow the following steps to pick up materials from a stockpile:

1. Begin the scooping operation by making an approach with the bucket lowered, level, and flat on the ground. If you tilt the bucket too far forward, it will dig into the ground. If you tilt the bucket too far back, it will ride up the face of the stockpile.
2. Next, place the range-control lever in 1st or 2nd gear (depending on the loader) and slowly approach the stockpile. Move the loader into the stockpile.
3. Manipulate the lift and tilt control levers simultaneously to curl back the bucket and raise the boom slightly until the bucket is full and completely rolled back. Do not let the tires spin as you fill the bucket. This will cause excessive tire wear and creates ruts and unsmooth work surfaces.

NOTE: If you are continually spinning tires, try a different gear.

4. Once the bucket is full or raised out of the stockpile, decrease the engine speed and put the direction-control lever in "R." Lower the bucket carefully and back out of the pile.

CAUTION: Never travel with a raised bucket! Your center of gravity changes dramatically, especially with a full load. This could cause an unstable situation and result in an accident.

Clamshell method

You use the clamshell method to pick up small piles of materials. The clamshell bucket, with its clam-like opening, is preferred over a solid bucket when handling sticky material that has a tendency to cling to the bucket. When handling (digging) material that is medium to hard, it's more efficient if this material is broken-up or loosened first by the use of a ripper. The following steps are for the clamshell method:

1. Begin by setting the bucket in the dozer position (OPEN), and push the material ahead (fig. 1–5). Do not push the material using the front part of the blade, as this is the weakest part of the bucket and may cause damage. When you have a pile, roll the bucket forward over the material so both cutting edges are level as shown in the SKID AWAY position in figure 1–5.
2. Now, close your clamshell. You do this by alternately pulling back on the clam-control lever and the bucket-control lever until the clamshell is completely closed. You'll find it easier to put the lift-control lever in the FLOAT position, then slowly close and roll the bucket back at the same time.
3. Also, you can use the SCRAPER position to spread the load. Set the bucket at the desired height and open the clamshell as you back up. As the material flows out, you can regulate the desired depth of spread by either opening or closing the clamshell.

4. Your final step in the process is to deposit the material into the dump truck. The positioning of the dump truck is important. Position the truck at right angles to your work (fig. 1–6). This position should be implemented any time you are loading, not just when using the clamshell.

If you are using the clamshell to deposit material, move the loader so the bucket is over the center of the bed. Simply open the clamshell, and the material will fall into the bed (fig. 1–7).

Figure 1–5. Clamshell method.

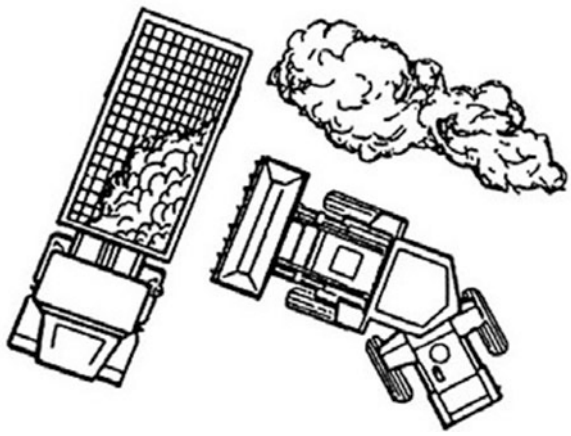


Figure 1–6. Positioning of dump truck.

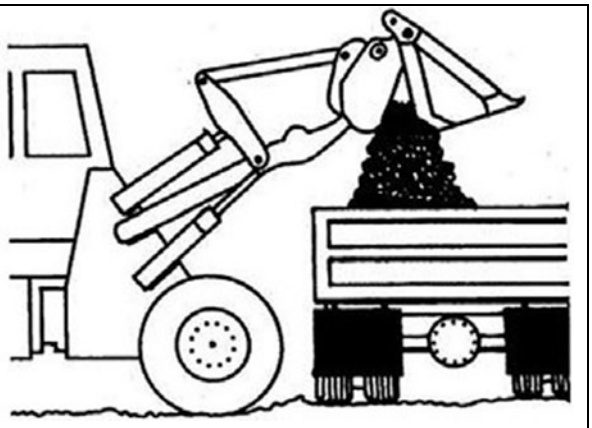


Figure 1–7. Loading a dump truck with the clamshell bucket.

Loading

Loading a dump truck with a front-end loader requires a safety-conscious, skilled operator. ALWAYS keep the following safety precautions in mind:

- *Never* load a truck with the operator sitting inside the cab. Have the operator place the truck in neutral or park, set the parking brake, and leave the truck. This prevents injury to the operator if a large object should crush the truck's cab during loading operations.
- Prevent electrical shock by *never* loading trucks under or near power lines.
- Always *attempt* to load the truck on the side opposite the fuel tanks. If the truck has multiple fuel tanks, be cautious that material doesn't spill out onto the tanks.
- Approach the dump truck, and *slowly* raise the bucket to a height just above the bed of the dump truck.
- Move the loader forward so the bucket is positioned *over the center* of the truck bed. Then, roll the bucket forward until all the material is out of the bucket. To keep from damaging the dump body, dump the first load a little at a time.

- Take care, so that the material is loaded into the center of the bed, and the truck is *not overloaded.* Placing the material on one side of the bed causes the truck to lean to that side and makes it difficult to steer. An overloaded truck puts excessive stress on the truck's frame and can cause a traffic hazard when the material falls off onto roadways.
- Once the bucket is empty, you back away from the dump truck, lower the bucket, and return to the stockpile for another load of material.

Return-to-dig operation

The return-to-dig is a mechanism located on the tilt cylinder. It consists of a rod running up a tube assembly and tripping a switch that stops the bucket from rolling back any further. After you dump the bucket, pull the bucket lever back into the ROLLBACK position, and then push the lift arm lever forward into the FLOAT position. The bucket lowers and automatically returns to the DIG position after you dump the load. This permits faster cycle time by letting you concentrate on maneuvering the front-end loader and less on manipulating the controls. At the end of the cycle, the bucket lever automatically releases from the ROLLBACK position and returns to the HOLD position. The lift arm lever remains in the FLOAT position and must be manually returned to the HOLD position.

Backfilling

The front-end loader is a handy tool for backfilling ditches or trenches. By lowering the bucket to grade level and drifting material forward, the machine pushes the stockpiled earth into the trench. This work is ideal for the scoop loader as long as the bucket is as wide as or wider than the tracks or wheels. Narrow buckets cause the wheels or tracks to ride up on the stockpile. This raises one corner of the bucket and may cause the lower end to dig into the earth, which causes accuracy issues and can damage existing grounds and pavements. When using a front-end loader with a narrow bucket, backfill the area from an angle.

Leveling operations

There are two ways to level areas with the front-end loader. One way is to use the 4-in–1 bucket in the DOZER position to push down the piles you are leveling (fig. 1–8). Remember, you are leveling the area, not digging, so pay attention to what the blade is doing. Set the blade at or slightly above the level you are trying to achieve.

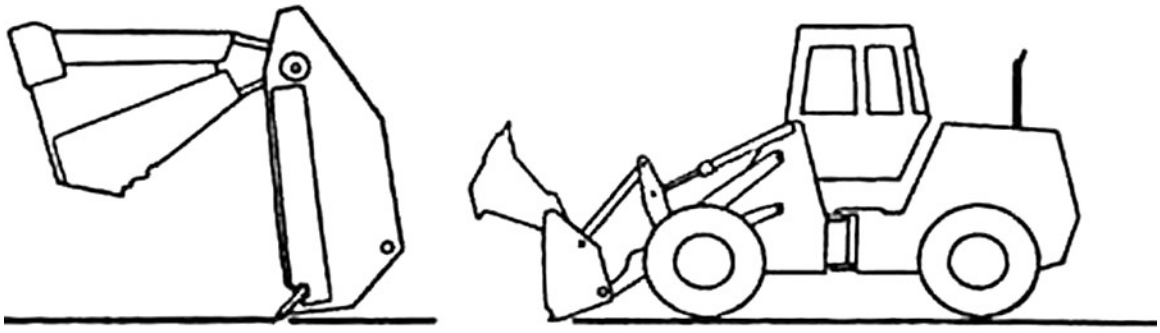


Figure 1–8. Leveling operations.

The other way to level a surface we call back dragging. To back-drag, lower and slightly tilt the loader bucket backward until it sets on the ground. Tilting the bucket backward keeps the bucket teeth from penetrating the ground and leaving small ruts. Now, slowly move the loader backward. As you start to move, place the lift-control lever in the FLOAT position. Continue moving until all the material underneath the bucket is gone. You may also find it necessary to slowly lift the bucket to spread excess material.

Stockpiling materials

The standard machine for building stockpiles is the front-end loader. The dozer can do the same work, but less efficiently, because it cannot make high piles without walking on them. Stockpiling is best done on areas that are flat, hard, and clear. Avoid low areas where drainage is poor and where a hard rain may fill low spots and wash away needed materials.

When you start to build a stockpile, level the bucket on the ground, and proceed forward in low gear until you penetrate the material. Raise the engine speed high enough to push the material ahead without spinning the tires. Push the material to the predetermined area and stop. Raise your bucket and dump the material. If trucks are still delivering material, having them dump close to the pile is the most efficient. When you finish stockpiling the material, maneuver the front-end loader around the pile so you can clean up the sides, and keep the pile in a uniform shape.

Be aware that different size aggregates in a material being stockpiled have a tendency to separate from each other—this is called segregation. If you work the material too much, segregation takes place with the larger particles rolling to the bottom of the pile. To avoid this, build your stockpile in layers to make sure it maintains a uniform gradation.

Attachments

You can use a variety of attachments with the front-end loader, thereby, increasing its flexibility and versatility on a number of jobs. You can quickly change attachments such as the boom and blade through the use of a quick coupler system. On a quick coupler system, use the following steps when changing an attachment that uses the hydraulic hoses.

Removing the attachment

Keep safety in mind as you remove attachment, be aware or pinch points and utilize proper PPE. To remove the attachment, follow these steps:

1. Shut the loader engine OFF.
2. Take pressure off the hydraulic lines by pulling the hydraulic levers (lift, tilt, and clamshell) toward you, then pushing the levers away from you.
3. Disconnect the hydraulic hoses. Disconnecting the hoses before uncoupling the attachment prevents the attachment from coming off and damaging the hoses.
4. Release the locking pins to uncouple the attachment. The pins are released using a lever inside the operator's cab. You may need to manipulate the attachment for the pins to release.
5. Slightly raise and curl the attachment forward then lower the attachment while backing the loader up at the same time.

NOTE: Always use extreme care when disconnecting the hydraulic hoses from a loader because hydraulic fluid may be hot and can burn your skin if you come in contact with the fluid.

Installing the attachment

If you are unfamiliar with a certain model of equipment, refer to the operator's manual, ask for assistance, and follow these steps to install the attachment:

1. Lower and curl the loader frame forward.
2. Be sure the hydraulic lines are clear before connecting the attachment.
3. Drive forward, placing the loader lift frame up and into the attachment frame. Curl the attachment backward and insert the locking pins. You may need to wiggle the attachment to correctly seat the locking pins.
4. Shut the loader engine off.

5. Take pressure off the loader's hydraulics by pulling the hydraulic levers (lift, tilt, and clamshell) toward you, then pushing the levers away from you. You may have to do this several time to release the pressure.
6. Connect the hydraulic lines.

Boom

You can use expandable booms to lift and spot materials ranging from manholes to precast concrete. The boom attachment has a somewhat higher lift capability than a bucket and is more convenient for some operations. Also, the mobility of the machine and its ability to work in restricted areas qualify it for many hoisting and moving jobs.

Blade attachment

You can use the blade attachment on a front-end loader in the same action as a dozer (fig. 1–9). You can complete leveling, pushing, and back filling an area with the blade attachment for small to medium-type jobs. You can also use them for snow removal operations. With a blade, the machine is able to turn in its path without climbing onto the edges of the material it is pushing. The blade is very effective because you can change the tilt with the dump control to meet changes in the terrain.

Figure 1–9. Blade attachment.

Postinspection/maintenance

A qualified person must perform all maintenance actions. Safety is a key factor during maintenance procedures. Always ground attachments, set the parking brake, and turn the loader off before doing any maintenance inspection. After using the front-end loader, your inspection may include, but is not limited to the following:

- Cleaning all debris from machine (inside and out), especially cylinder rods and affixed safety decals. Replace any missing or illegible decals.
- Washing any dirt or grease from the loader; this will help you find the lubrication points on the specified lube chart.
- Inspecting the loader for worn or damaged components. Repair or replace them before its next use. Any replacement components installed during repair must include the components' current safety decals specified by the manufacturer to be affixed to the component.
- Cleaning air intake filters. There are generally two elements, the inner and the outer. Under dusty operating conditions, clean outer elements daily (even more often if working conditions are extremely dusty). The inner filter will be replaced during regular scheduled maintenance. For cleaning procedures, use guidelines stated in the operator's maintenance manual.
- Lubricating the vehicle according to intervals listed in the maintenance chart. If operating the machine in severe conditions, lubricate the machine more frequently.
- Fuel the loader at the end of each working day to prevent moisture from condensing and forming droplets of water within the fuel tank. Contact base fuels to come to the job site if your equipment can't be driven to the service station (i.e., extreme distances, tracked vehicles, nondrivable support equipment, etc.). Ensure the vehicle has a minimum of three-fourths tank of fuel at the end of the duty day.

203. Compact track loaders

Figure 1–10. Compact track loader.

CTL comes in many shapes and sizes from several different manufacturers. They are arguably one of the most widely used pieces of equipment in a CE vehicle fleet. This is due to their size and ease of operation combined with an abundance of available attachments. All this adds up to an indispensable piece of equipment in our arsenal.

The CTL is a highly maneuverable and rugged machine (fig. 1–10). Because of its compact size and versatility, it can operate in areas where many standard size front-end loaders would be restricted, thus eliminating excessive handwork. When equipped with quick coupling devices, its ability to rapidly change attachments makes it very useful under a wide range of conditions.

Many of these loaders are relatively lightweight, ranging from one to six tons. These loaders have independently controlled drive trains powering both sets of wheels. This means the wheels are in a FIXED position with the power trains propelling the machine and steering it as well.

Preinspection

Just like the front-end loader, you must inspect the CTL before operating it. Start with a 360-degrees walk-around inspection. Using the AF Form 1800 as a guide, look for damage to the machine, such as leaks and other items that are required for any other type of preinspection. Then, move the inspection to the engine area. Check all the fluids, belts, and so forth. Check the applicable TO or owner's manual if you are unsure as to which type of fluid the equipment requires. When you get ready to begin your operation, always let the engine and hydrostatic system warm up. After warming up, operate the engine at full throttle so the loader can work efficiently at maximum power. If you need to operate the loader more slowly, move the steering controls a small amount while maintaining full throttle.

Travel controls

You control the travel of the CTL with two operating levers; they can be floor or hand type, but one is located at each side of the operator's seat (fig. 1–11). On this model, these levers are spring loaded and return to the NEUTRAL position when released. The hydraulic resistance then acts as a service brake to stop the machine. This design also acts as a safety factor because you must keep both hands on the levers when the machine is in motion.

To move the machine forward, push both operating levers forward. To reverse the machine, pull or press both operating levers back toward you. When you want to turn the machine right, gradually push the left lever forward. You do the same with the right lever to turn the machine to the left. If you move the levers in the opposite directions, one side propels forward and the other backward; this spins the machine around within its own body length. To maintain safe control of the machine, always move the levers slowly. Only small movements are necessary to move the machine.

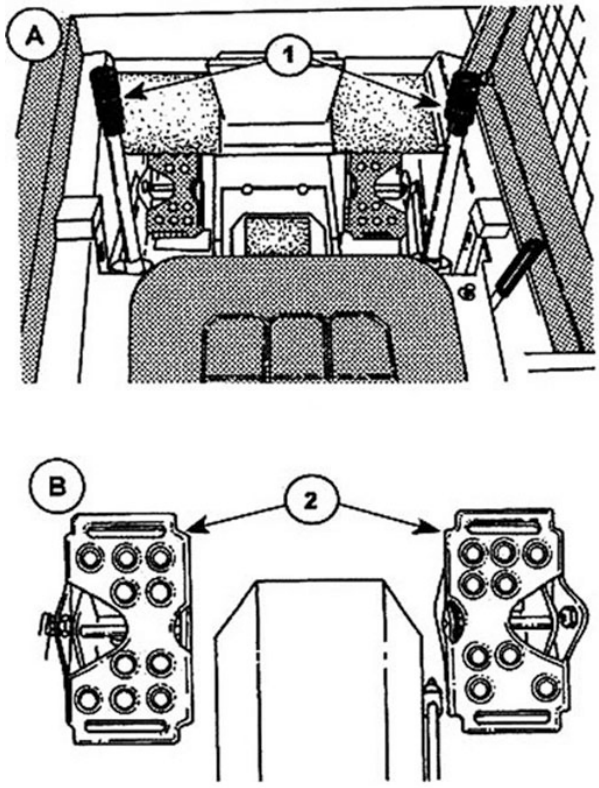


Figure 1–11. Travel controls (A) and bucket controls (B).

Bucket controls

Depending on its configuration, either two rocker foot pedals or two hand type controls manipulate the lift arms and the bucket tilt functions. To raise the lift arms, you depress the bottom (heel) of the left pedal or pull back on the left arm control shown in figure 1–11, views A and B. To lower the arms, you depress the top (toe) of the left pedal or press forward on the left arm control. The right pedal/right control arm controls the bucket tilt control. To tilt the bucket backward, depress the bottom (heel) of the pedal or pull back on the right arm control.

To tilt the bucket forward, depress the top (toe) of the pedal or push forward on the right arm control. When you want to level an area, put the bucket in the FLOAT position. This allows the bucket to follow the contour of the ground. To put the bucket in float, depress the toe of the lift pedal all the way forward until the pedal locks in position. If your CTL has arm control, press forward on the left until the lever locks into the float position. When you want to release the FLOAT position, depress on the bottom (heel) of the lift pedal/pull back on the left control arm and it will unlock.

Compact track loader operations

Operating the CTL includes the use of attachments to include operating the CTL with the loader-type bucket and postinspection and maintenance.

To increase its versatility, many attachments are available for the CTL. To perform a wide variety of jobs, auxiliary quick couplers are mounted on the loader to make changing attachments easy and flexible. Some attachments you may use include the impactor (breaker), earth auger, backhoe, sweeper, and forklift tines. Before installing any attachment, always refer to the operator's manual for the correct procedures for your model.

When an attachment has hydraulics, an auxiliary hydraulics system must be used. Usually, there is an auxiliary switch located in the operator's cab which must be ON, and then, the attachment is controlled with toggle switches located on the travel control levers or some other convenient place. Let's take a closer look at these attachments and how to install them.

Install the impactor

Impactor (concrete breaker). To install the impactor and earth auger attachments for the model shown previously, follow these steps: Keep safety in mind and wear proper PPE while installing impactors and follow these following five steps:

1. Before you enter the operator's cab, disengage all of the mounting frame levers.
2. Drive the loader forward to the attachments frame until the top edge of the mount frame is under the flange views A and B (fig. 1–12).
3. Tilt the mounting frame backward until the breaker is lifted off the ground.
4. Push down on the mount frame levers until they are in the LOCKED position View C (fig. 1–12).
5. Route the hoses from the impactor (breaker) under the tilt cylinders and connect them to the auxiliary hydraulics quick couplers.

NOTE: Check that both wedges extend through the holes of the breaker-mounting frame view C (fig. 1–12).

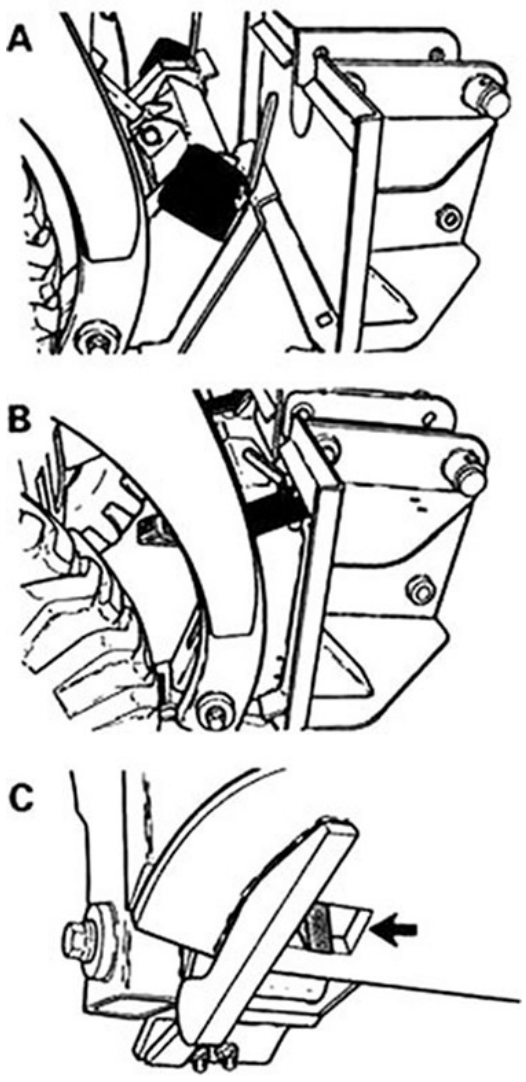


Figure 1–12, Views A, B, and C installing attachments.

The impactor attachment is typically used to break up concrete. This could be on a large project on the airfield or a smaller project like a deteriorated sidewalk in base housing. There are a few positions to consider when breaking concrete with an impactor. When operating the impactor on flat material, the following positions will maximize your efforts:

- Keep the tool vertical or curled back a small amount to direct the impact force downward and slightly toward the loader.
- When operating in the HORIZONTAL position, work near the edge.
- Keep the impactor perpendicular to the work surface.
- Apply penetrating force (no more than 15–30 seconds) by raising the front of the loader slightly off the ground.
- Avoid excessive sideways force; this can cause binding, poor breaking, and wear on the tool shank, cylinders, and breaker attachments.

Earth auger

The steps for installing the earth auger frame are the same you used installing the impactor. To operate the earth auger, adhere to the following steps:

1. Raise the lift arms and tilt the mounting frame forward until the auger is not contacting the transport bar and is over the location for the hole.
2. Lower the lift arms until the auger touches the ground.
3. Engage the auxiliary hydraulics on the loader so that the auger turns in a clockwise direction. At the same time, slowly lower the lift arms to drill into the soil.
4. Raise the lift arms often to remove the spoil from the hole.

Forklift attachment

Most CTLs have fork tines available for lifting and moving small items around the job site. Each fork tine has a maximum weight load capacity that is based on the size and weight of the CTL. Attaching the fork tines to the CTL involves the same steps shown in figure 1–12, views A, B, and C. Lifting and tilting the forks requires the same action as lifting and tilting the bucket. The main thing to always remember when using the forklift attachment is never try to lift more than the maximum weight allowed for the machine being used.

Sweeper

The sweeper is another of the hydraulically operated attachments that you might use often. The sweeper on a CTL operates pretty much like the dump truck-mounted brooms that you may have seen state road crews use to clear light snow. What you see is a cylindrical broom with a metal hood covering the top half, all mounted on a hinged hydraulic operated broom. To operate the sweeper, you need to determine whether the material you are to sweep is loose or packed down.

If it’s loose, drive up to the debris and engage the auxiliary hydraulics so that the broom begins to rotate. Next, lower the lift arms until the broom contacts the ground. Angle the broom in the direction in which you wish to cast the material. Note how hard the broom is contacting the ground. The harder the bristles hit the ground, the more wear is caused and the slower the broom will rotate. For packed down debris, approach the debris at a much slower speed. This allows the bristles time to come in contact with the packed debris, hopefully flicking it loose rather than riding up over it. If the material still proves too hard, it may be necessary to switch to a bucket and scrape the material loose. It also helps at times to raise and rotate the broom. This helps to empty debris out of the broom.

The key to any good sweeping operation is that you have a good broom; this is true with the CTL sweeper attachment as well. To ensure good sweeping action and avoid damage to equipment or bystanders, be sure you have a broom pattern that is only two to three inches wide. This broom pattern allows the tips of the bristles to dig into and break up the debris while sweeping the material. If the broom wears out to the point that you can’t achieve this two to three inch pattern, then it’s time to replace the broom with a new one. Remember safety is always paramount when operating equipment.

Operating procedures with loader-type bucket

Be sure to always warm up the engine prior to any operation. When traveling with a full bucket, travel up or down the slope with the heavy end toward the top of the slope. When traveling downhill with an empty bucket, travel forward with the bucket in front, leading the way down the slope until you reach a flat surface.

Excavating

First, lower the lift arms all the way and push the top of the tilt pedal/pushing forward on the control lever until the cutting edge of the bucket is on the ground. Now, drive forward slowly and continue to tilt the bucket down until it enters the ground. As you drive forward, push the bottom of the tilt pedal/lever control a small amount to increase traction and keep an even digging depth. Continue to drive forward until the bucket is full. If the ground is hard, raise and lower the cutting edge of the bucket while driving forward slowly.

Loading material

Lower the lift arms and level the bucket. Slowly contact the pile and curl the bucket. Remember that you achieve more power by moving the steering levers as little as possible. It is very easy to spin tires on a compact track loader. You may need to raise the bucket slightly to get a full load. Once the bucket is full, slowly back out of the pile and dump the material into your dump truck, trench, or wherever you need to dump it. When loading into a dump truck, make sure it will be able to effectively reach over the sides and dump properly. If the truck is too tall, don't try loading it. This creates an unsafe situation because the CTL becomes unstable.

Backfilling

Lower the bucket until the cutting edge is level on the ground. Drive the loader forward, pushing the material toward the edge of the hole. Tilt the bucket forward as soon as it is past the edge of the hole. Depending on the material, you may need to raise and tilt the bucket forward to empty the bucket.

Leveling

Leveling with a CTL is simply pushing material forward with careful bucket manipulation or by back-dragging. For back-dragging, tilt the bucket until it is almost perpendicular to the ground. Lower the lift arms and place them in float. Drive backward, leveling the loose material. Begin curling the bucket as you reach the end of the area you are leveling to "feather" out the material. Never travel forward with the lift arms in float. If the bucket keeps riding up on the material while back-dragging, you might need to take the lift arms out of float and apply down pressure.

Rapid airfield damage repair

There are some additions to the CTL attachment inventory, thanks in part to the new rapid airfield damage repair (RADR) techniques and sustainment pavement repair kits (SuPR) being introduced to our contingency operations. Below is a brief introduction to these attachments; you will get a deeper understanding of their contingency roles later.

Wheel saw

The wheel saw attachment (fig. 1–13), is designed with a carbide tipped wheel saw blade allowing it to be used to cut through a variety of material. It is powered by the CTLs hydraulic system. A hydraulic motor on the saw powers the saw blade. Hydraulic cylinders are used to control the depth of the cut made by the blade, while also maneuvering the trench cleaner to provide a clean bottom to the trench. They operate with minimal damage to the surrounding jobsite and eliminate the mess associated with excavations. Wheel saws are a key attachment within the RADR process used to cutaway damaged pavement for quick removal and repair.

Figure 1–13 Wheel saw.

Cold planer

The cold planer attachment (fig. 1–14), is made of a high-speed drum fitted with conical bits that quickly remove asphalt and concrete prior to resurfacing pavement. They may be used to rapidly remove unsound material and prepare an area for placing repair material. The cold planer attachment for CTLs is designed for small paving jobs in residential and commercial applications. Cold planers are primarily used to economically restore asphalt and concrete surfaces to a specified grade or level. They work well when you are milling imperfections in pavements prior to doing resurfacing jobs. They are also used for removing cracked or deteriorated pavement. Planer attachments are ideal for jobs where weight restrictions limit the use of full-sized dedicated planers.

Figure 1–14. Cold planer attachment.

Asphalt burner/mixer

The asphalt burner (fig. 1–15), is a new piece of equipment that is very useful when repairing large asphalt patches, such a utility cuts across a road or large potholes. The burner is an attachment designed to connect directly to a CTL. The mobility of the CTL allows the materials heated by the asphalt burner to be placed in tight locations. The burner is capable of heating up to 400 lbs of mix to 340 ° F in just 8 minutes. Remember that extreme caution should be exercised when placing materials that have been heated by the asphalt burner due to this high temperature.

Figure 1–15. Asphalt burner/mixer.

Concrete mixer

The concrete mixer attachment can be fixed to the CTL to provide a high level of flexibility for concrete operations. This mixer is efficient and rugged. It allows operators to mix, transport, and dump concrete much more quickly than a traditional stand-alone mixer. It is much easier to use for mixing small amounts of concrete which otherwise requires the use of a wheelbarrow. The compact size of the attachment makes it ideal for working in areas with limited-access space and hard to reach areas. The concrete mixer attachment can be used when working on sidewalks, installing fence posts, and finishing concrete work.

Tow equipment

The CTL can be used to tow equipment. Figure 1–16 shows a tow bar fixed to the forklift attachment of a CTL. This tow bar attachment allows the operator to reach into areas with limited-access, connect to equipment, and carefully tow equipment through areas that simply cannot be performed using other equipment. Equipment operators working with the SuPR kit will be some of the first to have the opportunity to train and use this attachment.

Figure 1–16. Tow equipment.

Towing using the tow bar attachment requires practice. It is simply not intuitive how a piece of equipment attached to the tow bar will respond when being turned. For example, when the tow bar is moved to the left, the rear end of the equipment being towed will pivot to the right. Operators using the tow bar attachment require a safety spotter who can closely watch equipment that is being towed. The key to using the tow bar is the actual wheel speed when towing. Operators need to drive as slow as possible.

Postinspection/maintenance

As with most machinery, you must complete a post inspection and maintenance process before the end of each workday. Always clean out any trash or debris from the inside of the cab. Clean air filters as required by owner's manual/TO or the operating environment. Wash any dirt or grease from the loader; this helps you find the lubrication points on the specified lube chart. Be sure to lubricate the vehicle according to intervals listed in the maintenance chart. If you are operating the machine in severe conditions, lubricate the machine more frequently. To prevent moisture from condensing and forming droplets within the fuel tank, fuel the loader at the end of each working day. Contact base fuels to come out to the job site if you can't drive your equipment to the service station. Ensure the vehicle has a minimum of three-fourths a tank of fuel at the end of the duty day. Before you leave the work area, conduct a 360-degree walk around checking for obvious damage or maintenance items.

204. Scrapers

Scrapers are designed primarily for loading, hauling, and spreading material during the initial earth-moving phase of construction. The ability of the scraper to load, haul, and spread material in one normal working cycle makes it desirable for most earth-moving projects.

There are two types of scrapers used in construction projects: the self-loading and the push-type. The AF mainly uses the self-loading scraper. This type is typically a single-engine auto loader (*conveyor or paddles aid in loading) or a dual-engine four-wheel drive machine. It has two parts: the tractor and the scraper assembly*.

Tractor

The tractor contains the engine, drive train, hydraulic pumps, and operator's cab. The tractor is connected to the scraper by a vertical kingpin swivel connection (articulated like a loader). This connection is usually in two parts with upper and lower pins. When you are steering, this connection permits turns of 85–90 degrees to each side of the centerline of the scraper. This allows the machine to be highly maneuverable; it can often be turned within the length of itself. There may also be a longitudinal and horizontal hinge that permits the two sections to tilt independently from side to side.

Scraper assembly

There are three operating components of the scraper assembly: the bowl, the apron, and the ejector. On a duel-engine scraper, the second engine would be mounted in the scraper assembly to power the rear wheels.

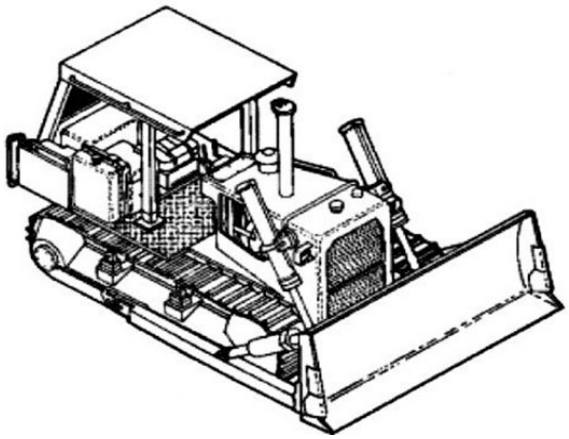


Figure 1–17. Bowl.

Bowl

The bowl is basically a box with rigid sides with the apron as a movable front and the ejector as a movable back (fig. 1–17). The bowl, which can be raised or lowered, is the load-carrying component of the body.

A cutting edge is bolted on the front bottom of the bowl. This cutting edge is made of wear-resistant steel and can be replaced like any other cutting edge. The center portion of some cutting edges is positioned ahead of the two side portions for deeper penetration. This protruding center section can also be referred to as the stinger.

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 edges.

NOTE: Replace the cutting edges that are worn to prevent wear of the scraper bowl.

Apron

The apron forms the forward section and a variable amount of the bottom of the bowl assembly (fig. 1–18). When closed, it rests at the cutting edges. A lever in the operator's cab hydraulically controls the apron. When the apron is lifted, it moves upward and forward far enough to leave the entire front of the bowl open. You can adjust the opening size to regulate the amount of material entering (during the cut) or leaving (the spread) the bowl.

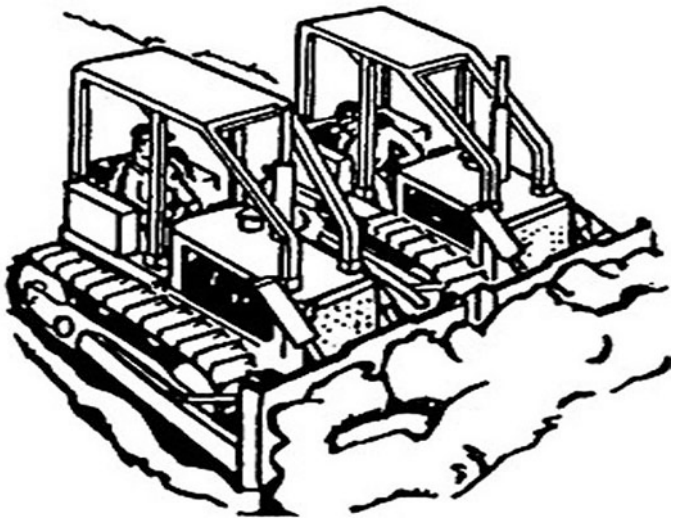


Figure 1–18. Apron.

Ejector

The ejector is the rear wall of the bowl (fig. 1–19). The most common ejector is hydraulically controlled and moves 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.

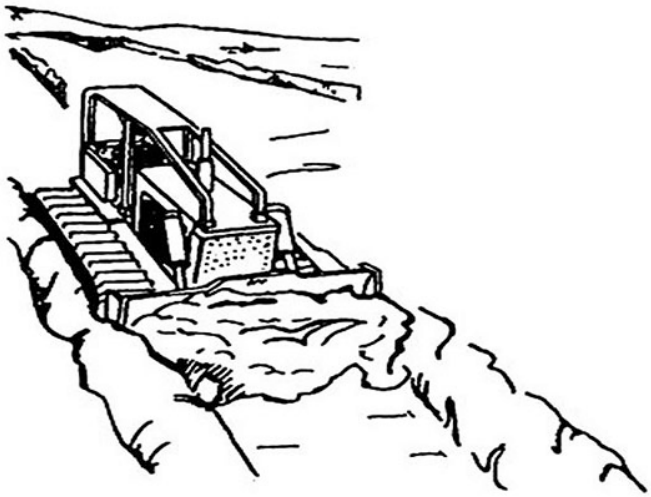


Figure 1–19. Ejector.

Operating range

It is important to understand the limits of the scraper. The efficient operating range of a scraper is approximately 300 feet. Cuts longer than 300 feet can be wasteful and inefficient. The scraper can work alone if necessary, but production is usually increased when it is assisted by other equipment. Support equipment for scrapers normally includes rippers, dozers, graders, and a water distributor.

Loading

The scraper work cycle has four phases of operation: loading, hauling, spreading/unloading, and returning to the cut. Since the loading operation is the most complicated phase of the operation, our focus is in this area. We can do loading several ways: downhill, straddle, backtrack, shuttle, chain, and pusher 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 four to eight inches above the leading edge of the bowl), and then lower the bowl to cut a depth of one to one and one half inches. The gear in which you engage the transmission depends on the nature of the material being cut. For light, loose material, use a relatively high gear. For heavy, compacted material, use a low gear; 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 cutting edges of the scraper and forced into the bowl by the forward motion of the scraper. Avoid spinning the scraper tires during cut operations. Spinning the tires is nonproductive and causes expensive premature wear of the tires, differential, and transmission.

The material entering the bowl moves back against the ejector and forward against the apron. When the bowl is filled to capacity (commonly called “heaped”), close the apron, and at the same time, raise the bowl one or two inches above the ground. This helps to spread loose material falling off the bowl and not create piles. 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.

Downhill loading

Downhill loading uses the force of gravity on the scraper to move larger loads in less time. The added force of gravity is 20 pounds per gross ton of weight per one percent of downhill grade. The downhill pull adds more material per load, and the added material weight increases the total gravitational pull.

Figure 1–20. Straddle loading.

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 makes a cut, the second scraper makes a parallel cut and leaves a four- to five-foot-wide island between the two cuts (fig. 1–20). The third scraper can straddle this island of material to achieve a fast, less resistant load.

NOTE: The following methods are depicted using a pusher, but the patterns can be mimicked using a self-loading scraper.

Backtrack loading

This is a method where the cut is fairly short, and loading in both directions is impractical. As shown in figure 1–21, too much time is spent backtracking and maneuvering for the next load. When the cut is wide enough, use other loading methods.

Shuttle loading

We use shuttle loading for short cuts where it is possible to load in both directions (fig. 1–22). The pusher pushes one scraper in one direction and then turns and push loads a second scraper in the opposite direction.

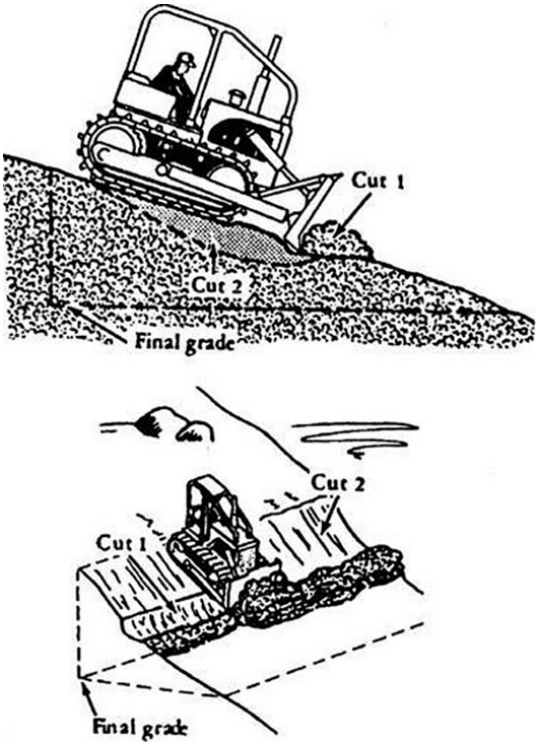


Figure 1–21. Backtrack loading.

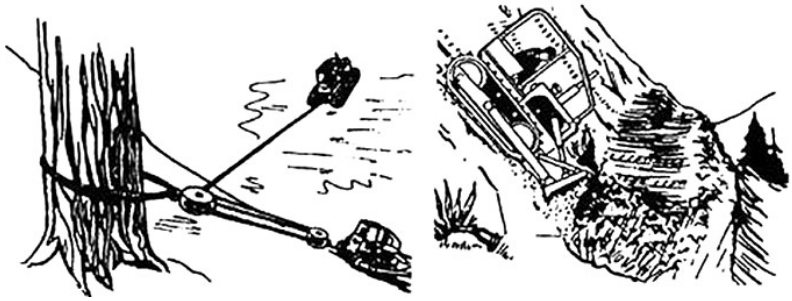


Figure 1–22. Shuttle loading.

Chain loading

We use chain loading where the cut is fairly long, making it possible for the pusher to pick up two or more scraper loads without back tracking (fig. 1–23). The pusher loads one scraper, then moves in behind another scraper, moving parallel to the first one in the adjacent lane.

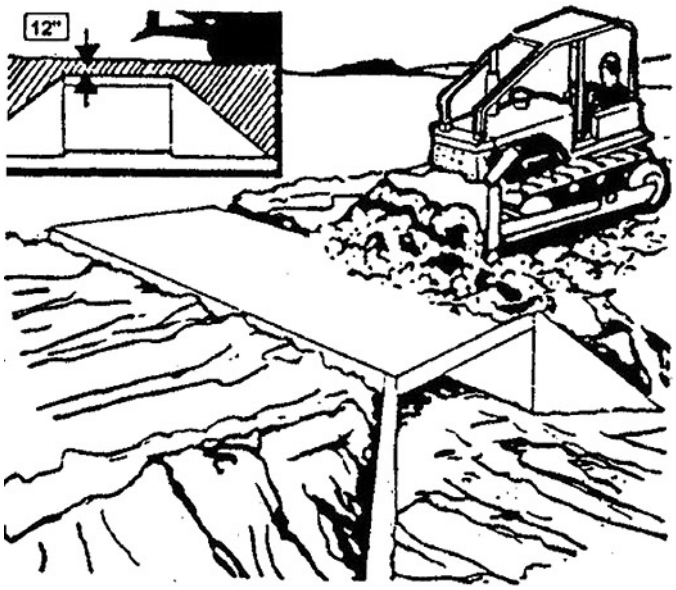


Figure 1–23. Chain loading.

Most scrapers have a prime mover (tractor or other vehicle) that is used to pull the scraper blade through the ground when loading. The prime mover also tows the scraper assembly when traveling and controls the moving component parts of the scraper assembly while spreading. To use the scraper efficiently and effectively, you need to know the techniques for performing each operation. Scraper production techniques are used to achieve the most amount of work with the scrapers assigned.

Pusher loading

We use bulldozers in this operation to achieve maximum productivity. A scraper may load without assistance, but generally, it is more economical to use pusher assistance to reduce loading time. With few exceptions, pusher assistance for scrapers is essential to decrease loading time and to decrease tire spinning. This method increases the tire life on the scraper.

Optimum loading is an operation when loading time and maximum output are critical. Push-loaded scrapers should be loaded within one minute and within a distance of 100 feet. More time and distance may be used to obtain more material—but only when the haul is long enough, and the added material is great enough to offset hauling fewer loads because of longer loading time.

When scrapers are backed up at the cut waiting for pusher assistance, let the scrapers cut without attaining a heaped load. When pushers are waiting for scrapers, use the time to dress the cut. In some cases, it increases production by allowing the scrapers to work in a smooth area.

Operators must enter the loading area at a controlled high-return speed. If the approach and cut are relatively level and smooth, this is a safe and practical practice. The cut supervisor or pusher operator indicates the loading lane. The pusher should be waiting about 45 degrees off the lane to be cut, allowing the loading unit to come in with the least delay and difficulty. The scraper operator starts the loading operation before the pusher makes contact. As the scraper speed decreases, the pusher makes contact and starts assisting in the loading operation. The pusher continues pushing after a full load is gained to give the scraper a boost out of the area.

The scraper leaves the cut as fast as possible, traveling a few feet before the bowl is lifted to the CARRYING position. This procedure spreads the loose material that has piled up in front of the cutting edge and results in a smooth cut, thus allowing the following scraper to maintain speed.

Maintaining adequate drainage throughout the excavation operation reduces compulsory downtime caused by bad weather. Operators must make loading cuts in such a manner that uniform graded slopes are constantly present.

Loading and spreading various materials with a scraper

Different materials require different loading and spreading techniques. For example, loam and most clay soils cut easily and rapidly with minimum effort. Loosen very hard clays with rippers or scarifiers before loading. Sand, with little cohesion between its particles, tends to run ahead of the scraper blade and apron. The finer and drier the particle, the worse this condition becomes.

Loading sand

When loading sand it is best to enter the loading area fast, lowering the bowl slowly, and picking up as much as possible by using the forward momentum of the tractor-scraper unit. This fills the hard to reach area of the bowl. Then, shift into a lower gear to match pusher speed and pump the bowl up and down. For best results in pumping, drop the bowl as the scraper rear wheels roll into the depression of the previously pumped area, then raise the bowl as the wheels are climbing out of it. To top off the load, drop the bowl sharply two or three times at the end of the loading area.

Loading rocks

Loading rock and shale with scrapers is at best, a difficult task. It also causes maximum wear and tear on equipment. Ripping eases the problem. In some soft rock and shale, the scraper with pusher assistance may be able to secure the load without prior preparation. When loading stratified rock, try to start the scraper blade in dirt moving in to catch the blade in planes of lamination, and thus, forcing material into the bowl. Pick up loose rock or shale on the level or slight upgrade with the blade following the planes of lamination.

Turning

Turn within the shortest radius possible and at the highest safe speed. When making turns to perform cut-and-spread operations, use the sequence shown in figure 1–24.

Figure 1–24. Cut-and-spread sequence.

Spreading materials

Planning is very important when spreading material with scrapers. The following techniques ensure you’re using the spreader properly during spreading operations:

- Spread the first load at the start of the fill.
- Travel with subsequent loads over the previous fill, provided lifts are small.
- Make each following spread start 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 scrapers' 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. 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.

Make the fill high on the outside edge (fig. 1–25). This prevents the scraper from sliding over the outside edge and helps in maintaining accurate slopes to desired heights. When you do not make the fill 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 the center up for drainage.

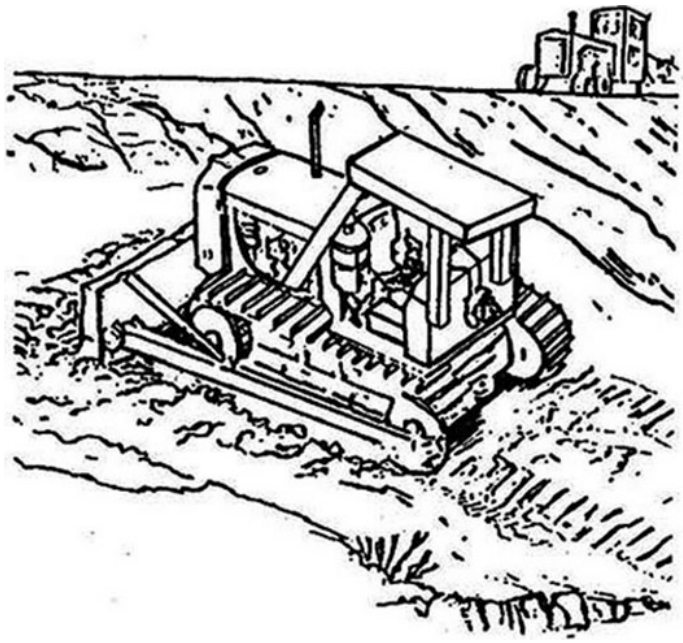


Figure 1–25. Proper placement of fill material.

Different materials require different dumping procedures. Spread sand as thin as possible to allow for better compaction and to make traveling over the fill easier. When operating in wet or sticky material, you may have difficulty in unloading and spreading. Working with this type of material:

- Do not try to make too thin a spread when unloading.
- Keep the bowl high enough to allow the material to pass under the scraper. Material not having enough room to pass under the scraper rolls up inside the bowl into a solid mass that is difficult for the tilt floor or tailgate to eject.
- Bring the tilt floor or ejector forward about 12 inches at a time for best results in wet or sticky material.
- Return the tilt floor or ejector approximately six inches after each forward movement, this allows the material inside the bowl to settle back and loosen up.
- Repeat this operation until the bowl is emptied.

Travel time principles for scrapers

Travel time includes haul time and return time. Here the power and characteristics of the scraper become of major importance. Plan the job to avoid steep grades because they can drastically reduce production. Lay out haul roads so no unnecessary time is wasted in maneuvering. Where grades permit, remember that the shortest distance between two points is always a straight line.

Avoid long slow turns because these turns mean longer and slower cycles. Make your turns as short as possible and at the highest speed consistent with safety. You can save valuable time on short-radius turns by using a figure-eight cycle whenever possible. During scraper work, you can eliminate as much as one-half of the turning by using this load pattern. If possible, load alternately at either end of the fill. An alternate method would be for the scraper to load at the central point and spread in opposite directions. Either method provides efficient use of equipment.

Space your machines for best efficiency. Remember, a scraper can travel only as fast as the machine ahead of it. It is often impossible for one scraper to pass another. Also, keep in mind, passing increases the chances of an accident. Operate your equipment to provide equal and proper spacing between machines. Speed up to close a gap or slow down to open a short gap. The safest and most efficient operation results where each machine operates at the same speed during each function in the cycle.

Dump at the end of the fill nearest the cut when lagging far behind the next scraper and at the far end when too close to the next scraper.

Haul roads must be kept in good condition. Eliminate ruts and rough washboard surfaces with a grader or dozer. If neither is available as the scraper operator, drop the bowl occasionally on the return trip to level the high spots and fill holes. A well-maintained haul road permits traveling at higher speeds, increases safety, and reduces operator fatigue and equipment wear.

On haul roads, use water distributors to reduce dust. Roads kept moist (but not wet) will pack into hard smooth surfaces and permit higher travel speeds. Dust tends to get into all parts of the scraper. Such a condition necessitates more frequent lubrication and causes more rapid wear of equipment parts; therefore, reducing dust increases equipment life and improves safety through better vision.

Once on the haul road, keep the unit in the highest gear that is safe for road conditions. The scraper automatically slows down on upgrades and soft footing. Slow it down for curves and rough spots, and when approaching other machines. A two-axle scraper has a tendency to bounce, which we call loping, and can be very uncomfortable to the operator and may reduce control of the scraper. When possible, carry the scraper bowl fairly close to the ground. This lowers the center of gravity of the scraper and reduces the chances of bouncing or upsetting. Always give way to a loaded scraper or truck when your unit is empty.

Always avoid lugging the engine. Lugging can cause severe damage to engine parts. Downshift to keep up the engine speed. Maintaining proper engine speed enables you to do the work quicker, accelerate faster, and operate more safely.

Post operation scraper inspection

As always, conduct a post operation inspection to ensure your machine will be ready for the next day. Areas of particular concern are tires, cutting edges and other wearable parts, cleanliness, and air filters. A good 360-degree walk-around is good insurance to make sure nothing happened during operations. Annotate any discrepancies, and get it turned in as soon as possible. Finally, make sure the scraper has at least three-quarters of a tank of fuel and ready to go.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

201. Dump trucks

1. Which two levers control the dump box?

2. If enough personnel are not available to conduct tailgate removal/installation procedures in the field, what is the bare minimum number of people needed, and what are their duties?

3. What can happen if you forget to latch the tailgate before leaving the dump area?

4. What are the procedures for spreading materials in layers?

5. What is the purpose of the safety pin on a pintle hook?

202. Front-end loaders

1. What is the main reason for inspecting your equipment?

2. When service is needed, who must fill low fluids such as engine oil and coolant?

3. What four functions can the front-end loader perform when it is equipped with the multipurpose bucket?

4. What is the bucket-control lever used for?

5. What happens when you pull back on the clam-control lever?

6. What are the two transmission controls on the front-end loader?

7. When would you operate the front-end loader with the range-control lever in position 1?

8. When is the front-end loader most efficient?

9. In what position should the bucket be when you start scooping?

10. When would you use the clamshell configuration?

11. How can you achieve greater efficiency when using the front-end loader to work with medium-to-hard material?

12. Why do you *never* load a truck with the operator sitting in the cab?

13. What two methods do you use for leveling areas with a front-end loader?

14. How can you avoid segregation when stockpiling materials with a front-end loader?

15. How do you release pressure on the front-end loader's hydraulic lines?

16. Normally, what must you do to correctly seat the front-end loader's locking pins?

17. What jobs are ideal for using a blade attachment with a front-end loader?

203. Compact track loaders

1. How can you operate the loader slowly, while still maintaining full throttle?

2. How do you move the machine forward and backward?

3. How are the CTLs auxiliary hydraulics engaged?

4. Which way should the impact force be directed when operating the impactor?

5. When do you travel with the bucket facing the top of the slope?

6. Which CTL attachment is meant to cutaway damaged pavement for quick repair?

204. Scrapers

1. What are the two distinct sections of a scraper?

2. What are the three basic operating components of a scraper assembly?

3. Why is the center cutting edge on the scraper bowl positioned ahead of the two-side pieces?

4. What is the efficient operating range of a typical scraper?

5. What are the four phases in the operating cycle of a scraper?

6. Which loading operation do you normally use where the cut is fairly short, and it would be impractical to load in both directions?

7. After loading the scraper, why do you travel a few feet before lifting the bowl to the CARRYING position?

8. When you must spread materials, where do you spread the first load?

9. How do you unload wet or sticky material?

10. What three things does a well-maintained haul road do for you?

11. When hauling, why is it desirable to keep the scraper bowl as close to the ground as possible?

12. What three things does maintaining proper engine speed do for you?

1–2. Material shaping equipment

The crawler tractor—commonly called a bulldozer, or dozer for short—has a large front-mounted blade. These blades vary in size and are designed to perform different earth-moving functions. The AF has many makes, models, and sizes of dozers. In this unit, we look at the controls of a general hydraulically controlled dozer, as well as, how to start and stop the machine. We also discuss how a rear-mounted ripper on a dozer can be extremely useful when doing work in an unprepared area or where the earth is very hard or rocky.

205. Bulldozers

You must exercise extreme caution and carefully analyze potential dangers before operating any heavy equipment, especially dozers. Use the equipment properly, so that it is not neglected or damaged beyond normal wear and tear. Whenever you operate large and complicated equipment in difficult circumstances, the operation increases the potential for personal injury.

Because of its high-pressure hydraulic system and diesel-powered engine, the crawler tractor is considered a complicated and dangerous piece of equipment (fig. 1–26).

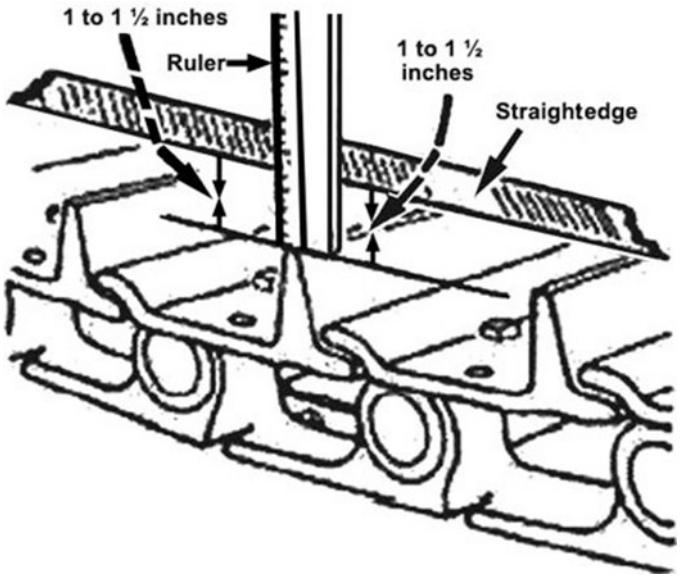


Figure 1–26. Crawler tractor.

Preinspection

You must complete a preinspection prior to operating any heavy machinery. To ensure you meet all preinspection requirements, use AF Form 1800, Operator's Inspection Guide and Trouble Report to do the following:

1. Check all items listed that pertain to the crawler tractor.
2. Inspect the vehicle's exterior by performing a 360-degrees walk around while you look for any damage or leaks.
3. Inspect hydraulic fluid sight glass for proper operating level (fill as needed).
4. Inspect mirrors and windows for cleanliness and damage.
5. Inspect hydraulic cylinders and hoses for any damage or leaks.
6. Inspect the tracks for adjustment and wear.
7. Sign the AF Form 1800 after you properly inspect the equipment.

Puddles of fluid on the ground or sticky dirty areas on the engine normally indicate problems associated with the machinery. Investigate and have them repaired as soon as possible.

Also, check the blade assembly for excessive wear, loose bolts, and visible cracks. Always check the drive engine and battery compartments for proper levels of engine oil, coolant, and transmission fluid. Inspect the drive belts for tension and alignment. Ensure the battery connections are secure and free from corrosion.

Finally, check the owner's manual or other inspection documents to ensure you have checked all recommended items. Annotate any discrepancies on the AF Form 1800, and notify your supervisor. Once you complete the preinspection, the equipment is ready to use. Remember, operating a dozer can be dangerous if you do not control it properly.

Dozer controls

Most dozers found in AF inventory are equipped with a hydrostatic transmission, which makes the transmission controls simple to operate. Most dozers have a control lever within easy reach of the operator to control direction of travel (forward and reverse) and range (gear selection). The control may be separate or combined. Frequently, dozer forward and backward controls use a single lever located to the operator's left. This lever controls both speed and direction. If you move the lever in the right, the dozer moves forward, and when you place the lever in the left slot, the dozer travels in reverse. The farther back you pull the lever, the faster the machine travels (higher gears). To reduce the speed, you simply move the lever forward (lower gears). The dozer stops when you move the lever to the NEUTRAL position.

Some dozer controls are configured differently, so familiarize yourself with the equipment you will be operating prior to operating it. The dozer in your unit may have similar controls, but they may not be located in the same place. Know your controls before you start the dozer.

Steering the dozer is done by several different means. Steering brakes actuated with your feet, a combination of foot brakes and steering clutches (levers you pull), and even joysticks are just a few examples of how to steer the dozer. Some newer dozers have the range, direction, and steering all incorporated into one easy to use hand control.

Starting and stopping

For the purposes of this lesson, we will be referencing a generic dozer. Always refer to the owner's manual prior to operating. To start the dozer, you must do the following:

1. Make sure the parking brake (located underneath the instrument panel) is set.
2. Push the neutral-lock control all the way down and pull the hand-throttle a quarter of the way open.
3. Turn on the electrical system master switch (located on the left side of the operator's seat, near the floor). Leave this switch on when the machine is running.
4. Engage the starter by turning the switch to start.
5. Pull up the neutral-lock control to the RUN position.
6. Warm up the engine and you're ready to move.

Raise the blade off the ground just high enough to clear any obstructions and pull the hand throttle all the way back (full throttle). While in operation, run the engine at full throttle. You control the speed of the dozer with the decelerator, range, directional controls, and the brakes.

To stop the dozer, do the following:

1. Move the speed and direction-control lever to the NEUTRAL position.
2. Push the neutral-lock control completely down and set the parking brake.
3. Let the engine run at idle speed for three to five minutes to cool the engine. You may damage the turbo charger if you don't allow for cool down.
4. Turn the master switch to the OFF position.

Operations

There is a great deal about dozer operation that you can only learn from actual experience. On the other hand, there are certain things that good dozer operators have learned that can be passed along to help speed you on your way to becoming a good operator.

Your dozer is hydraulically controlled. It makes no difference as to what type you have, as most hydraulically controlled dozers operate in the same fundamental manner. If you learn how to operate one specific dozer, it won't take you long to get adjusted to another model.

A control lever in the cab of the dozer hydraulically raises or lowers the blade. When you are becoming familiar with a new type of dozer, raise and lower the blade several times to get the feel of the blade control. A good way to become familiar with a new dozer is to practice moving the blade up and down over short distances (one-fourth to one inch). Of course, when the dozer blade is loaded with earth, it acts differently. With the added weight of material, the blade lift control reacts slower when you raise the blade.

Efficient operation of the blade

Efficient operation of the dozer blade enhances the equipment's ability to perform what's required. To effectively operate the dozer, do the following:

1. Shift the speed and direction-control lever to the FORWARD position, and move forward.
2. Lower the blade until it starts to cut the ground by using your right hand to control the blade control lever.
3. Raising the blade in small increments (about one-fourth inch at a time), when you feel the dozer starting to pull hard, you do this by short duration jerks on the blade-control lever.
4. Raise the blade to ground level, and push the material to the point where the material is being piled or used as fill.

If you raise and lower the blade as much as two or three inches during operation, the blade will cut an uneven surface on which the dozer must travel. The uneven surface causes the dozer to nose up and down. This causes the blade to cut more unevenly and increases the up-and-down nose action of the tractor.

To carry the load that you have on the blade, you must anticipate and compensate for the up-and down movement of the front of the dozer. When the dozer starts to nose up, compensate by lowering the blade. When the dozer starts to nose down, compensate by raising the blade far enough to lower the front of the tractor. Don't over compensate; raise and lower the blade only enough to raise or lower the front of the dozer.

After you become an experienced operator, you'll be able to raise and lower the dozer blade automatically as the front of the tractor moves up and down. You'll learn to do this without giving it a great deal of thought or special attention. You will be able to anticipate and compensate for the actions and reactions of the machine without consciously thinking about it.

Efficient bulldozing operations

You are bulldozing (dozing) when your job involves drifting material straight ahead in front of the blade. You'll be bulldozing when you are on a stripping job or other short-haul excavation.

There are three ways to increase the efficiency of dozing operations and increase the volume of earth you can handle in a day:

- Side-by-side dozing.
- Slot dozing.
- Downhill dozing.

Side-by-side dozing

This particular method of dozing eliminates the spillage of earth from the ends of the blades that are side-by-side and increases the yardage moved (fig. 1–27). If the haul distance is short, the time saved by this method of dozing is lost because of the time required for the second dozer to maneuver into position; therefore, use this method only on hauls of 50 feet or more.

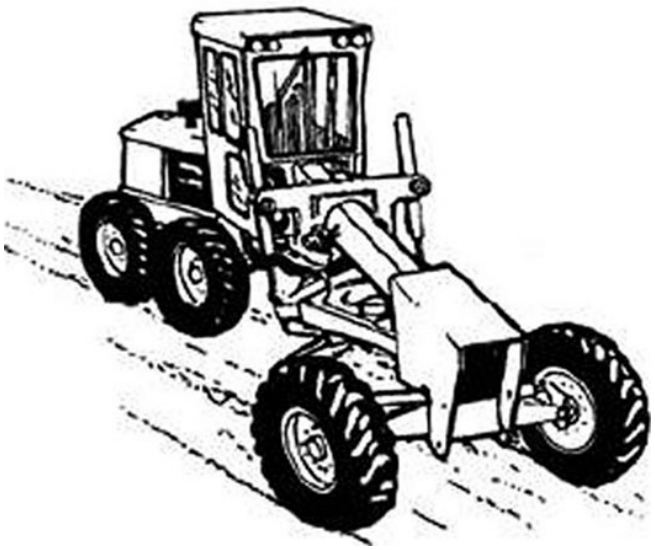


Figure 1–27. Side-by-side dozing.

Slot dozing

In this method of dozing, you use the spillage from the first few passes to build windrows that hold the earth in front of the blade (fig. 1–28). With the windrows acting as containment for the blade and keeping it at full capacity, it is possible to carry a heaping load without continually digging. If you are slot dozing, always work in the same tracks. If you are operating an angle-dozer, you must set the blade straight across the tractor before you can slot doze. If the blade is angled, it will merely cast material to one side.

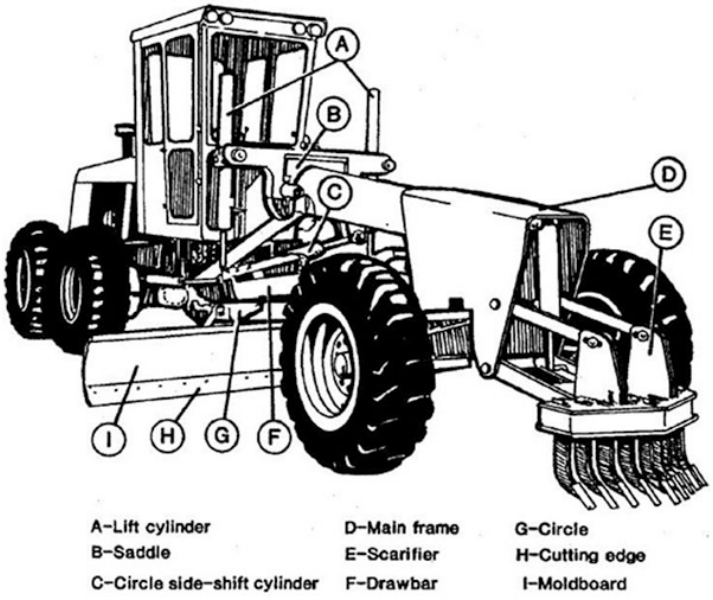


Figure 1–28. Slot dozing.

Downhill dozing

With the help of gravity, your dozer can push a bigger load of material downhill than you can during level dozing or uphill dozing. Plan your job so that as much work as possible is downhill. When dozing down a steep hill, it is not necessary to make a trip down the hill with each load. Instead, push several loads to a pile at the edge of the hill and make one pass to the bottom. Downhill dozing is one of the easiest and most efficient methods of boosting production with a dozer.

Use of a rear-mounted ripper attachment

Using a dozer with a rear-mounted ripper greatly expands its capability by providing a means to break up hard materials (e.g., frozen ground). We use dozer rippers primarily for the same purpose as other types of rippers, but they have better earth-breaking capabilities due to their size and construction.

The ripping effect is created when you apply down pressure on the hydraulic ram between the dozer and the toolbar, thus using a portion of the dozer's weight to increase the downward pressure. The attachment of the rear-mounted ripper to the dozer does not seriously affect the maneuverability of the dozer, as the overall length is increased only 30–40 inches depending on the model.
You can raise the ripper out of the way during normal operations, and return it to operating position by manipulating a control lever.

Some ripper teeth are pivoted vertically to permit individual teeth to move around small obstacles contacted beneath the surface. If you are ripping material and the dozer continuously lags or stalls, stop the operation and reduce the number of teeth. Always remove and install the teeth equally on each side. If you are ripping hard material, use one tooth mounted in the center.

A towing hitch can be mounted on the back of the ripper. This allows the dozer to tow equipment when the ripper is not operating. On some dozers, the rear-mounted ripper is mounted in place of a drawbar. In this configuration, the dozer can't be used to tow attachments.

When you are using the dozer to perform ripping operations, do not turn or use the dozer in reverse; this could damage the dozer. It is best to operate the dozer in low-range or slow-track speed and use the maximum number of teeth rather than operating at a faster speed.

Removing brush, trees, rocks, and boulders

Clearing and earthwork operations involve the excavation, transportation and placement, or disposal of materials. Clearing operations involve repetitive work cycles that remove or move brush, trees, rocks, and boulders from the excavation site. Normally, earthwork can involve many pieces of earthmoving equipment. If you plan on using an angle-dozer, set the blade straight in the BULLDOZING position.

Dozing brush and trees

To clear brush and small trees, travel forward with your blade lowered into the ground only as far as it takes to cut the brush and tree roots. It may be necessary to back up occasionally to clear the blade of roots and material collected.

To remove medium trees, raise the blade as high as it will go, ease into the tree in low-track speed and push. As the tree falls over, back up and lower the blade under the exposed roots. Raise the blade to lift out the trunk and roots of the tree as the dozer travels forward.

Removing large trees takes more time and effort. First, check and see if it is a "pushover." Raise your blade high and try pushing on the tree. Keep an eye on the tree branches when you start to push.

There is always the possibility of dislodging dead limbs, which can fall and not only damage the cab but also injure you. Give the tree a few short pushes timed to coincide with the swaying movement set up in the upper part of the tree. Never charge or run up against the trunk of the tree at full speed. Dozers are ruggedly built, but they won't take that kind of punishment.

If the tree doesn't push over, you need to cut its roots. If the tree has a large root system, do the following:

1. Determine the direction in which the tree will fall, and then make a cut in the roots on the opposite side to a depth sufficient to cut some of the larger roots. (Not making a cut on the side to which it is going to fall causes the roots to help prevent the tree from falling back on you when you are working around it.)
2. Make similar cuts on both adjacent sides.
3. When you finish cutting the roots on three sides, fill in the first cut and make a ramp.
4. Proceed up the ramp with your blade lifted high and push.
5. As the tree starts to fall, reverse the tractor quickly to get away from the rising root mass.
6. Move forward into the fallen tree, pushing and raising your blade at the same time to extract the roots.

If it appears the tree can't be cleared using this method, it may be necessary to cut the roots on the fourth side. It is easier to remove an entire tree with a dozer than it is to cut it out and remove the stump later. The reason for this is that the additional leverage gained by the height and weight of the treetop provides a contributing force that assists in bringing the tree down.

If you need to remove a stump, you employ somewhat the same procedure as you use in pushing over a tree. Since it is impossible to push high up on a stump, you have to cut deep enough around the roots to get the dozer blade below the roots. When the blade is below the roots, move forward with your dozer, and raise your blade at the same time. This procedure will take out most stumps. Move the debris away from the area and fill the hole in, then transition to the next tree.

Dozing rocks and boulders

To dig out rocks and boulders, you proceed in much the same way as you do to dig out stumps. Each rock will probably take a different procedure; however, here are some general pointers for removing rocks.

Usually, you first dig around the rock with your blade and work one corner of the blade down under the rock. When the corner of the blade is firmly caught under the rock, you move the tractor forward, raising the blade with a lifting and rolling action to roll the rock out (fig. 1–29).

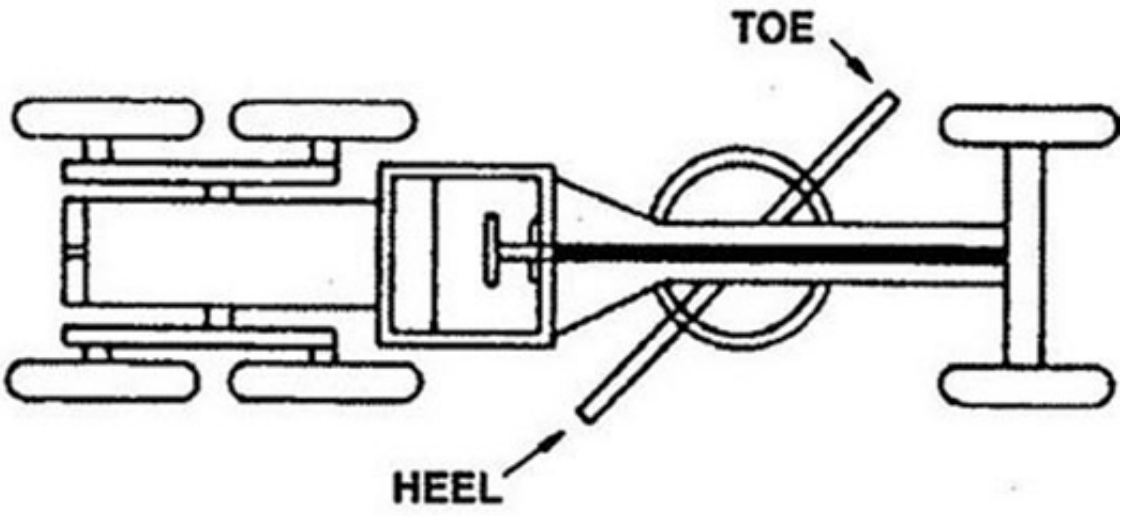


Figure 1–29. Dozing large rocks.

Side-hill cutting

During road construction, side-hill cutting is probably the most important job a dozer can do. An angle-dozer is best for this operation because it can prepare level benches on which scrapers can operate. You work the dozer from the top of the proposed road downward, and take full advantage of favorable grades to increase productivity. When it is difficult to get the dozer to the top of a proposed road, the effort you expend in developing a pioneer trail more than compensates for the increased output.

Look at figure 1–30 to see the correct method for starting a side-hill cut on average terrain. You start the cut by working straight down the hill. Make short passes to bench out an area large enough so that you can eventually turn the dozer and work parallel to the slope.

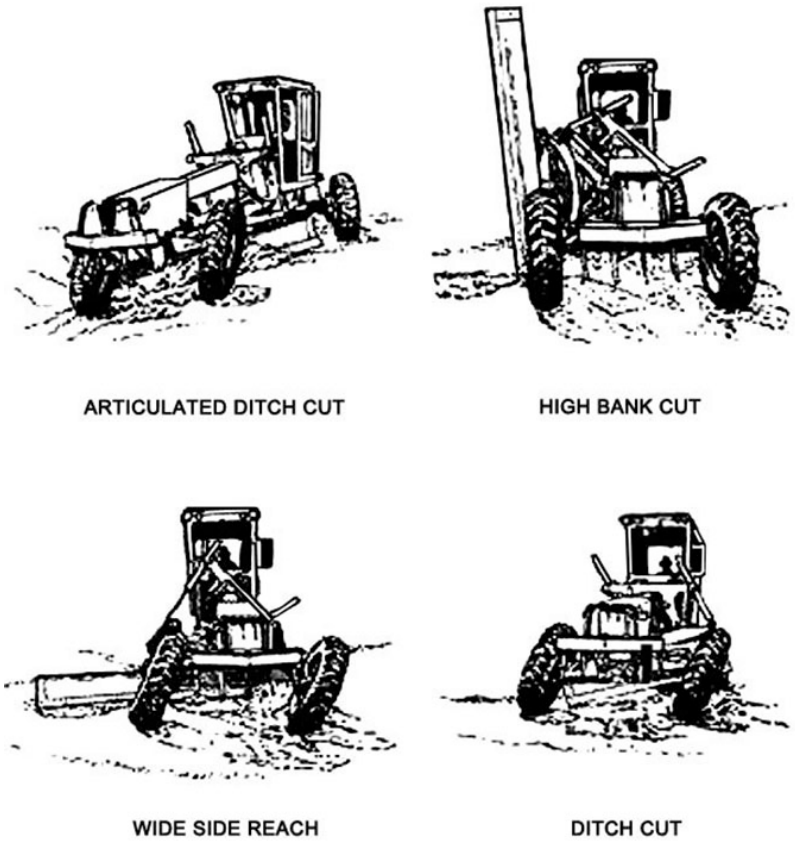


Figure 1–30. Starting a side-hill cut.

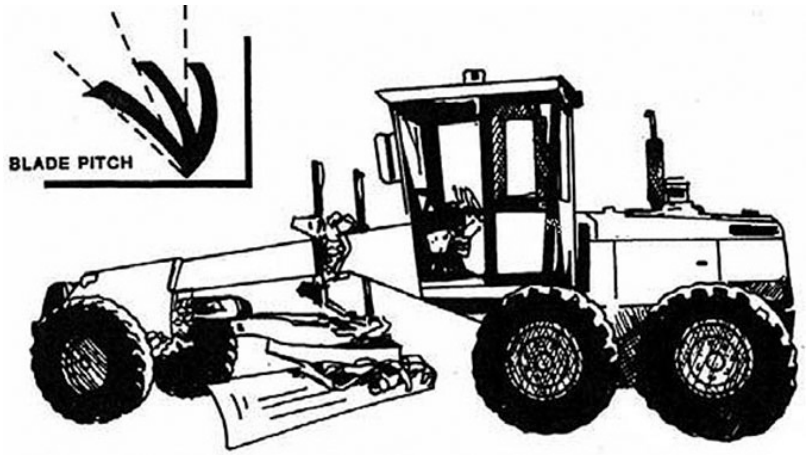


Figure 1–31. Cutting road and vertical force.

For exceptionally steep terrain, you may need to hang a block and tackle on a tree or an anchor point, and use another dozer to pull you up the hill (fig. 1–31). If your dozer has a suitable winch, it can pull itself up. As we said before, cut just enough so you can turn the dozer and work parallel to the slope. Be mindful of the slope when you turn; a dozer will slide sideways down a steep slope. After you turn parallel, proceed with the work by cutting into the hillside and pushing the material over the low side. You can do this best with an angle dozer; however, you can do it with a regular tilt dozer by making short swinging passes to drift material over the side. Back up just enough to get another bite after each time you push material over the side. Be careful to keep all cuts sloping into the hillside and cut wide enough so that scrapers following you will have their wheels on solid footing.

Digging ditches

Digging V-shaped ditches is another job you can do with your bulldozer or angle dozer. Especially suited for this type of work, an angle dozer is a bulldozer with an angled moldboard to push earth to one side. When using an angle dozer, angle and tilt your blade before digging. Line up your dozer parallel to and about two feet from the stakes marking the ditch and make a light cut the length of the ditch. Back up and get your outside track on the windrow thrown up by the first pass, then make another cut. Keep your cuts light so that you have good control over the blade and can handle the material. Now, turn the dozer around and cut the other side of the ditch. This gives you a V-shaped ditch.

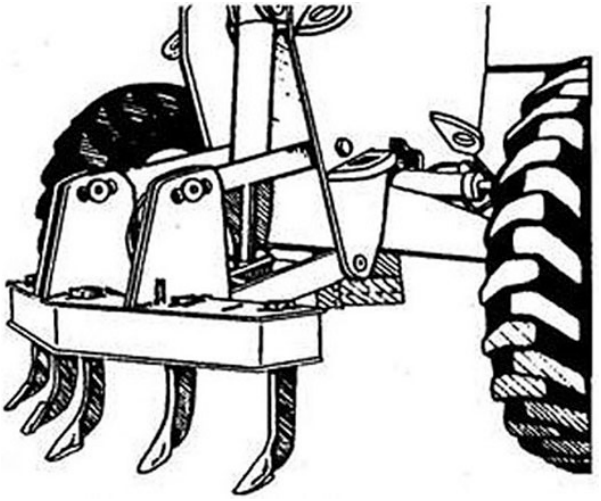


Figure 1–32. Backfilling a culvert.

Backfilling

Dozers are the best equipment for backfilling because material is pushed directly ahead of the machine over banks into ditches or directly against a structure. Figure 1–32 illustrates a method used to backfill culverts and abutments. When backfilling culverts, do not cross the culvert unless there is 12 inches of solid material on top of the culvert.

Angle dozers are excellent for backfilling ditches, as they drift material into the trench while maintaining forward motion. With straight-blade dozers, you can obtain the best results by approaching at an angle and ending each pass by swinging into the trench, culvert, or structure. When the haul is over 300 feet, it is more efficient to have scrapers or trucks haul material to the dozers that are working at backfilling.

When compaction of backfilled material is necessary, the fill is constructed and compacted in layers, or “lifts.” These lifts vary in thickness depending on the type of fill material; however, do not use dozers for compacting fill. The dozer attains much of its all-type-terrain versatility from its low ground-bearing pressure at the track. This pressure varies from only about six to nine pounds per square inch (psi), depending on the particular model. You compact the fill using rollers or tampers. Be careful when backfilling around and over culverts to assure proper compaction without damage to the structure or pipeline.

Finishing

Finishing any excavation or construction project with a dozer is one of your more difficult jobs. It takes skill and practice to do it correctly. To finish doze, you must start at a point that is level with the finished grade. Before you lower the blade, place the dozer in motion; then lower the blade gradually and feed it into the ground. Make sure your tracks are level as the blade enters the ground. If you drop the blade suddenly, it will gouge into the ground.

Counteract the up-and-down movement of the front of the dozer by raising and lowering the blade to keep the work level. Usually you’ll find that if you operate the dozer at the highest speed possible without pulling the engine down, and keep the blade at least one-half full of material, the finished work will be smoother. By doing this, your blade cuts the high spots easier, and the extra material fills in the low spots.

After you finish part of the job, use the finished work as a guide for the rest of the job by allowing approximately one-fourth of the blade to overlap the finished work to guide the cut and the spread.

If you have an angle dozer, you may find it advantageous to angle the blade on some jobs. Never attempt to finish with the blade tilted to one side; always ensure the blade is perfectly level before starting out.

Finishing side slopes

Using a bulldozer to finish a side slope can be a little challenging and requires patience and practice to become proficient. Don't get discouraged, use these two commonly used methods for finishing side slopes with a bulldozers:

- Working parallel to the slope.
- Working diagonally to the slope.

When finishing side slopes, you start the dozer at the top and work parallel to the right of way (fig. 1–33).

Figure 1–33. Dozing parallel to side slope.

Earth from each pass falls to the lower side of the blade and forms a windrow that is picked up on succeeding passes, filling irregularities in the terrain. Be careful not to allow the blade corner to dig as this may increase the slope beyond job specifications.

When finishing side slopes, start the dozer at the bottom and work diagonally up the slope (fig. 1–34). A windrow is formed and is drifted continually to one side to fill low spots or irregularities. This method is one of the few instances where you may efficiently use a dozer working uphill.

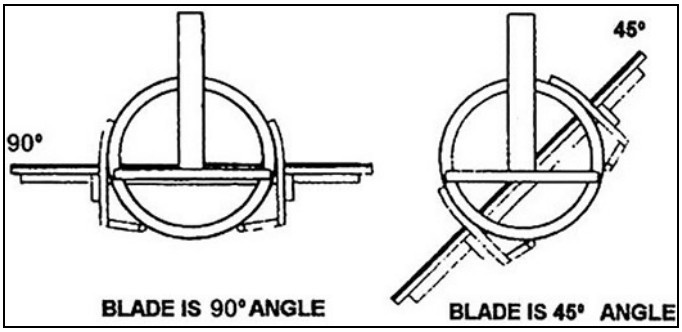


Figure 1–34. Dozing diagonally to side slope.

Making fills

Fills are usually obtained from cut, excavated earth, or other material hauled in from an outside source. Doze the fill material within one foot of the slope stake. Compact this material as you complete the fill to ensure a solid base that will not settle.

Using the appropriate roller is the best way to compact fill material. The compaction of fill material often forces material out to the stakes; ensure the stakes are not covered during any of the operation, because they are needed for future reference.

Constructing stockpiles

Some construction projects may require you to perform cutting and stockpiling operations with your dozer. To do this, you need to keep the dozer at low-track speed, and then, gradually lower your blade

until you obtain the desired depth of cut. You may have to make a considerable number of passes to bring the cut to the desired depth if the cut is deep. When you begin to make your cut, increase the track speed to compensate for the resistance as the load increases. Maintain your cut as level as possible. At the end of your cut, gradually raise your blade to avoid creating an abrupt ridge or bump in the path of the dozer. Let the material fall off the blade to form a ramp at the completion of your cut.

As you stockpile the material, keep the approach moderately inclined and at least two dozer blades wide. Do not operate the dozer where you will go beyond the point required to retain firm track support. When you back the dozer off the stockpile, do not raise the blade too high as this puts extra weight on the front idlers and causes greater track penetration. You will probably have to make successive cuts in constructing the stockpile. When you do, make the stockpile higher on each pass until it reaches the desired height or you complete the cut.

When trucks deliver material, have the loads dumped close to each other. This keeps the material in one area and reduces maneuvering time for the dozer. The manner in which you handle loads dumped from a truck during stockpiling depends on the nature of the material. You can handle and stockpile course-grained aggregates (such as sands) and single-sized aggregates in almost any manner with little, if any, segregation; however, aggregate blends require special handling.

Let’s say you have material with both course and fine particles (aggregate blends). Segregation will occur if you stockpile these materials with sloping sides (a cone shape). The larger particles will roll down the slope. You can reduce this by stockpiling in layers. When using a dozer to stockpile blended aggregates (i.e. base course), build up the pile in uniform layers of about four feet thick. Try to keep the handling of the material with the dozer to a minimum, because each movement of the aggregate can cause both segregation and degradation. If the dozer works too long on the stockpile at the same level, the grinding action of the tracks will break down the larger particles. This problem is not just limited to track-mounted vehicles, but can also occur with rubber-tired equipment.

Designing and constructing berms

Typically, *large berms* are constructed of compacted soil using crawler tractors. In reality, you can use any type of earth moving equipment to construct berms. For military purposes, berms are constructed to conceal and protect equipment and personnel. The sides must have a ratio of at least 1:1 slope or be sloped at the angle of repose of the soil. The angle of repose of a soil is the steepest angle at which the soil is still stable and doesn’t slough or fall down the slope. The minimum width at the crest is determined by penetration calculations for the ballistic threat, or two to three feet as a practical minimum for construction and maintenance. The top of the berm should have a 10:1 slope to minimize water ponding on the berm crest and then soak into the berm. Construction is usually completed using heavy grading equipment, and sides are usually faced with sod or sandbags to control erosion. Berms can be constructed against walls or as freestanding structures.

When operating a dozer or another type of heavy equipment to build a berm, there are three main areas you should have knowledge of before starting any type of berm construction: the berm’s crest, height, and base.

Berm crest

The width of the crest of the berm is a key design variable. The relatively large space requirements of soil berms and the large volume of earth that must be moved make it desirable to minimize this width. The width at the crest of the berm is designed for the ballistic threat that may be encountered. The degree to which this thickness must defeat the ballistic threat depends on the protection requirements and the construction of the structure. For example, in the case of a thin walled, nonhardened structure, it is desirable that the berm completely prevents the incoming projectile from reaching the wall; however, with a semi hardened, reinforced concrete structure, it may only be necessary to slow the incoming projectile so that spalling (chip, break, or splinter) of the concrete wall does not occur.

Berm height

The berm height must be sufficient to protect the structure from the fragment spray or incoming projectile. It is recommended that you set the height at least equal to the height of the structure or as high as practical. If time permits, you can perform a more detailed analysis.

Berm base

The allowable side slope of the berm face determines the width of the base of the sloped portion of the berm. In practice, for expedient situations, the maximum practicable slope is the natural angle of repose of the soil; however, the gentler the slope (i.e., the smaller the slope angle) the greater the protection provided and the greater the stability of the berm under repeated attack, especially during inclement weather. If the soil type is unknown or time is not available to properly compact the soil, it is generally conservative to use a 1:2 slope for preliminary design or planning purposes (i.e., calculation of space requirements and soil volume to be moved). For cohesive soils, greater slopes can typically be sustained; however, consideration must be given to the potential for the moisture content of the soil to vary. If time permits, you can perform a slope failure analysis as described in standard soil mechanics texts or handbooks. Remember this is just the basic information on berm construction. Later, you will receive the information to build different types of berm for contingency purposes.

Berm maintenance

The biggest problem after you build a berm is erosion. To maintain the integrity of the berm, there are several ways to prevent erosion from the elements of weather and rodent infestation. The type of berm maintenance required is generated by the use of the berm. A few examples would be berms used for personnel protection, fuel bladders, and small arm fire ranges.

The two main weather sources for erosion are rain and wind. To combat rain and wind, there are several methods of surface treatments that prevent major repair to any berm. The most common type of erosion control for rain is grass seeding the berm after construction. Once the grass seed grows, the grass acts as a wick and allows for the rain to travel down the berm slop to drainage channels that carry water away from the berm. Other treatments for erosion are soil cement or bitumen sprayed over the surface of the berm. Both types penetrate the surface of the berm to act as a hardening agent, which repels water away from the berm structure. The two main downsides to these types of treatment are environmental issues and the short life span of the treatment. Always ensure you obtain environmental approval before using these types of materials for repair. The second problem for the cement or bitumen type of surface treatment is, over time both treatments may become brittle and wash away during a heavy rain or blow away during high winds. The last major berm maintenance issue that might arise is rodent infestation.

Rodent infestation is a major problem that can be treated many different ways. The most common ways are using a wire mesh under the last couple of inches of the berm's finished surface. This action helps by acting as a barrier that keeps the rodent from burrowing deep into the heart of the berm. The other way to control the rodent infestation is to attain the services of the environmental control section for the use of mechanical or chemical means to control an infestation.

Using a dozer as pusher

As a dozer operator, you may use your dozer as a pusher (push cat) to help load scrapers. Your dozer may be equipped with a regular blade that is mounted with a push block or with the blade removed and a special pusher cup substituted in place of the blade. You must take care when using the dozer as a push cat. If you push too hard, the scraper can jackknife and cause damage or injury. When turning, make sure the blade of the push cat does not come in contact with the rear tires of the scraper. If at all possible, avoid using angle dozers for push cats. Angle dozer blades are not adapted for installation of pusher blocks and are more lightly constructed than bulldozer blades. Angle dozer blades can become bent or severely damaged during this type of operation.

Towing equipment

Sometimes you may have to tow equipment with your dozer, such as a sheepsfoot roller. For this task, the dozer is equipped with a drawbar. To tow equipment with the dozer, slowly back up the dozer and connect the tongue of the equipment being towed to the dozer drawbar. You need a spotter to guide you and to make the actual tongue-to-drawbar connection. After you make the connection, insert the drawbar pin. BE EXTREMELY CAREFUL. You can cause your spotter to lose some fingers between the tongue and drawbar with one wrong move.

After you are hooked up and secured, start out at low track speed. Keep watch not only on what you are towing, but when you maneuver around other pieces of equipment. Remember, equipment being towed has the tendency to cut corners rather than to follow the prime mover. Be careful and try to avoid making sharp turns because this can cause damage to the dozer drawbar and the tongue of the equipment being towed.

Winching operations

A winch is a powerful rotary drum mounted on the back of the dozer. Wire rope is attached to the drum, which is wound in or out as the drum turns. The operation is usually a mechanical process controlled by a PTO mechanism. Other winches are operated by electric or hydraulic power. The winch we cover here is controlled hydraulically. Usually, the winch is driven directly by the engine's torque converter with power transmitted within the winch by means of two clutches for forward and reverse operation. When the winch is not being powered, the oil brake is automatically applied and the clutches are released.

The power of the winch is rated by the maximum pull it can exert on its line. Use special care to ensure the winch and dozer are in good operating condition and the wire rope is not damaged or worn. Always check to ensure others are not standing near the winch or line when it is under tension. 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 extend the life of wire rope and winch parts and avoid severe friction on the drum. If the work is heavy, you can reduce strain with the use of pulleys and multiple lines. When pulling from the winch, always be sure to pull straight off the winch. When wire rope is pulled at an angle, it slips sideways, which can cause damage to both the wire rope and winch. DO NOT operate the winch unless the dozer is equipped with a protective screen on the back to protect you if the line breaks. You can use the winch with the dozer either stationary or moving.

Stationary

In this situation, the dozer is stationary while the winch is used to lower or raise equipment that is working on steep slopes. When working in this operation, be sure you anchor the dozer adequately. If not, the dozer could slide when the loads are applied. Before you begin, be sure you line up the dozer with the pull. Gradually let out the line when lowering the equipment. You'll have better control by using partial throttle. When you raise the load, it may be necessary to increase the power over what was needed for lowering.

Moving

Here the dozer is working on a steep slope using the winch line to let the dozer down and pull it back up the slope. You secure the end of the winch line to another dozer, a structure, or tree sufficient to hold the dozer on the slope. To lower yourself, operate the dozer in a low forward gear or low track speed gradually letting the line out. To pull yourself up, put the dozer in low reverse while at the same time pulling the line in. Steer the dozer as needed to spool the line evenly back onto the drum.

Postinspection and maintenance

Dozer postinspection and maintenance, like any task, is very important. If the machine is not running well, then how are you going to get the job done? The more effective of a maintenance program you have for the equipment, the better your operation will run. Correct and timely operator postinspection and maintenance ensures that the equipment will do the job when needed and extends the life of the

equipment. This process saves the AF money. It also includes cleaning and servicing. You do all of these jobs in the performance of your duties.

Once you are done operating the dozer, you must spend time inspecting the equipment for mechanical discrepancies and other problem related areas that may have occurred while operating. This lesson presents a short list of inspection items that you must complete after you operate the dozer.

Keep the dozer clean

If you have mud or dirt all over your dozer, you won't be able to find lubrication points from the lube charts. It will also be hard to inspect the dozer for damage or discrepancies. Another place of importance is the area where the tracks ride over the rollers. Rocks and mud can build up in this area, which then cover the lubrication points. Rollers that are unable to move develop flat spots and may freeze in place if the tracks constantly move over them. Check and clean this area daily. It may be necessary to take a water truck to the job site to clean the tracks and associated rollers; this saves a lot of time compared to loading and hauling the dozer to the wash rack.

Fill the fuel tank

Refueling your equipment is easy if you are able to drive it to the service station. If you can't drive your equipment to the service station (you can't very well operate a bulldozer down the street to the service station), you must arrange for a fuel truck to come to the job site. Fuel your dozer at the end of each working day if the tank is less than three-fourths full to prevent moisture from condensing and forming water droplets within the fuel tank. Also, this ensures that the equipment is ready if needed in an emergency.

Most diesel-powered equipment has an oil water separator located in the engine compartment that must be drained periodically. Check your owner's manual for proper procedures for the vehicle you are operating.

Lubricate

Lubricate the machine according to the intervals listed in the maintenance chart unless you operate the machine in severe conditions. Then you have to lubricate the machine more frequently. Be sure to remove all the dirt from the grease fittings before you lubricate.

Adjust the track tension

To determine proper track tension, position the dozer on a hard flat surface. Then, place some form of straightedge over the front carrier roller and the idler (fig. 1–35). When checking the tension, remove all slack from the rest of the track. Track tension should be suitable for the type of area in which you are working. For example, track tension should be tighter when working in hard or rocky areas and laxer for sand and snow.

However, if you adjust the tracks too tight, 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. To loosen the track, do the following:

1. Loosen and remove the plug at the front of the track adjuster and/or cover.
2. Loosen the valve in the track adjuster to let some of the grease out.

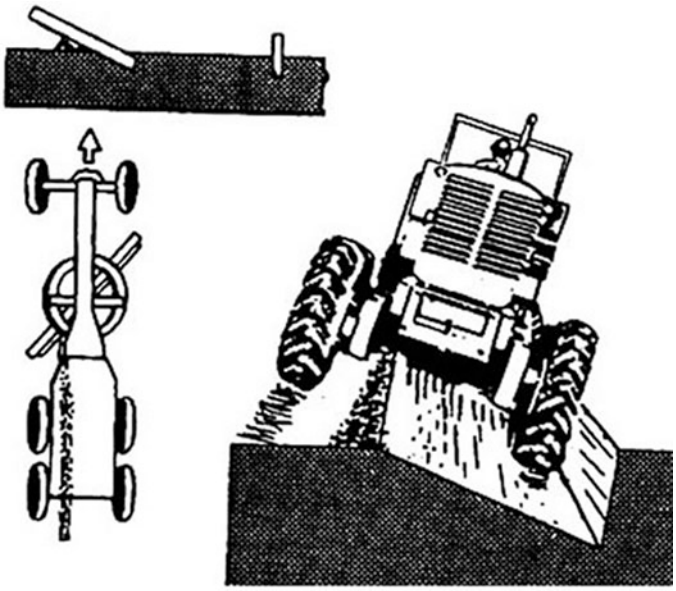


Figure 1–35. Checking track tension.

3. Drive the machine forward and backward several times to loosen the track.
4. When the track loosens, put a straightedge over the track between the carrier roller and the idler wheel.
5. Measure the distance from the bottom of the straightedge to the top of the track plate. Compare this measurement with what is recommended in the owner's manual for your specific dozer as each dozer could be different.
6. When the track is adjusted, reinstall the plug.

Tracks that are too loose fail to stay aligned and tend to come off when the tractor turns. As a result, the idler flanges, roller flanges, and sides of the sprocket teeth wear down. A loose track whips at high speeds, which can damage the carrier rollers and their supports. The drive sprockets may jump teeth (slide over the track bushings) when the tractor moves in reverse if it is too loose. Should this happen, the sprocket and bushings will wear rapidly.

If the track is too loose and you need to tighten it, add grease to the track adjuster, and move the dozer forward and reverse a few feet. When the adjustment is correct according to the manual, install the plug and replace any covers.

Clean air intake breathers/filters

Air intake breathers and filters are of special importance. An air intake typically includes a container which dust within the intake air stream collects. You need to inspect it visually daily and empty it when needed. This initial system draws some dust out of the intake air, but as it goes through a filtering system, the rest of the dust is removed. There are generally two elements within a filtering system: (1) the primary (outer) element and (2) the secondary (inner) element. Under dusty operating conditions, inspect the primary element daily (even more often if working conditions are extremely dusty).

Primary (outer) element

Check the dirty element for damage, especially the rubber seal on the end. Take your finger and push on the seal to see if it feels soft and if it moves back to its original shape when you release your finger. If it doesn't, discard the element. Remove the loose dirt with compressed air, but be careful as, compressed air directed at the element filtering material could damage it.

When using compressed air to blow out the filter, wear either a pair of goggles or a face shield. To wash the element, soak it in a mild detergent for 15–20 minutes, then move it up and down rapidly to loosen as much of the dirt as possible. Rinse the element with clean water, and let it dry before you reinstall it.

Secondary (inner) element

Normally, you don't replace the secondary element; however, it is replaced when the primary element is replaced. Maintenance personnel will replace this when the machine goes in for maintenance or when the prescribed number of operating hours has been reached.

Change cutting edges

Changing the cutting edge on a bulldozer is also a part of operator's maintenance. It is your responsibility to know how to change cutting edges and to ensure that they don't wear down into the blade base. Dozer blade bases cost thousands of dollars. Worn blades must be rebuilt (built up by welding) or replaced. Either method is expensive in comparison to replacing cutting edges.

The most important part of changing cutting edges on a bulldozer is to make sure that the cutting edge is blocked so that it can't accidentally drop or fall on you. Block the blade under the push-arms (the large framework extending from the machine frame to the blade). You do this by raising the blade, placing blocks under the push-arms, and lowering the push-arms onto the blocks.

Just as you do with graders, use some penetrating oil to loosen the rust off the bolt threads to make removal easier. Remove the bolts and blade. Most bulldozer blades have between two and three

cutting edges. You may turn the blade over and reuse it if it hasn't been used on both sides. Finally, check the end-bits as they may need to be changed also. Refer to the operator's manual or maintenance manual for specifics on the blade and the cutting edges.

Maintenance

Maintenance tasks and preventative maintenance actions are an important part of the dozer operator's job. Throughout this and other lessons, you have read many topics concerning maintenance procedures and tasks associated with heavy equipment operations. You should realize by now that general preventative maintenance and maintenance tasks include jobs such as equipment lubrication, installation of attachments, and equipment cleaning. Some other maintenance actions you may take as a dozer operator are as follows:

- Fasten attachments to tractor with clevis or wedge-pin hitches.
- Connect hydraulic hoses, belts, mechanical linkage, or PTO shaft to tractor to provide power to raise, lower, or tilt attachments.
- Grease, oil, and perform minor repairs on tractor components, using grease guns, oil cans, and hand tools.
- Proper maintenance actions are essential to the life span and safe operation of any heavy equipment.
- Never neglect the maintenance of your equipment.

206. Graders

The grader is an important part of the AF pavement and construction equipment inventory. It is an essential tool for constructing and maintaining airfield runways, roads, taxiways, and building sites. After we clear, strip, cut, fill, and establish a rough grade, we use the grader to finish the final grade. In addition to its main job of grade finishing, we can use the grader for ditching, sloping banks, spreading material, maintaining unpaved roads, breaking up hard spots (scarifying or ripping), and removing snow. Grader work must be precise when constructing roads, runways, and taxiways. To ensure this, a survey team sets the actual profile of such projects with survey markers. These markers establish the boundaries, centerlines, elevations, and so forth. As a grader operator, you must be able to read these markers, and operate the grader to develop the desired profile of the project.

The grader is a versatile construction machine that is capable of performing a variety of functions on the construction site. Let's review some of the primary functions of a grader, particularly as they apply to road building.

Graders have a diesel engine mounted on an articulated frame supported by a pneumatic-tired front-wheel steer system. Most are equipped with a power shift transmission, fully enclosed cab, hydraulically operated blade, and scarifier or ripper. We can drive the grader from one work site to another; however, for long distance moves we should haul it.

Preinspection

Just like other equipment discussed, you must complete a preinspection before you operate any machine. Always follow inspection criteria to ensure your machine operates at 100-percent efficiency and is ready to complete the task you're assigned.

Using AF Form 1800, Operator's Inspection Guide and Trouble Report, check all items listed on the form that pertain to the grader. Inspection of the grader begins with a 360-degree exterior examination in which you look for any damage or leaks. Puddles of fluid and dirty areas on the engine or ground normally indicate problem areas; investigate and make any repairs as soon as possible. Check wheels/tires for wear, ensure lug nuts are tight, and correct air pressure in all tires. Check the hydraulic fluid sight glass and fill it as needed. Check mirrors and windows for cleanliness and cracks. Check hydraulic cylinders and hoses for any damage or leaks. Annotate any discrepancies

on the AF Form 1800 and notify your supervisor. Now think about the moldboard assembly (the blade) and what you might examine. Examine the cutting edge and end-bits for excessive wear, loose bolts, and any cracks. Next, inspect the engine and battery compartments. Ensure the battery connections are secure and free from corrosion. Check engine oil, coolant, transmission fluid levels and fill as needed. Examine the drive belts for wear, tension, and alignment. Once you complete the inspection, make sure you sign the AF Form 1800 indicating that you have conducted the inspection. To help you fully understand why inspections are needed, let's take a look at how the grader works. You'll find the grader to be a multipurpose machine. The grader in figure 1–36 has articulated steering which allows it to maneuver much better than the older nonarticulated types.

Figure 1–36. Articulated steering.

Components

Figure 1–37 and the accompanying table identify some of the major parts and attachments of the grader.

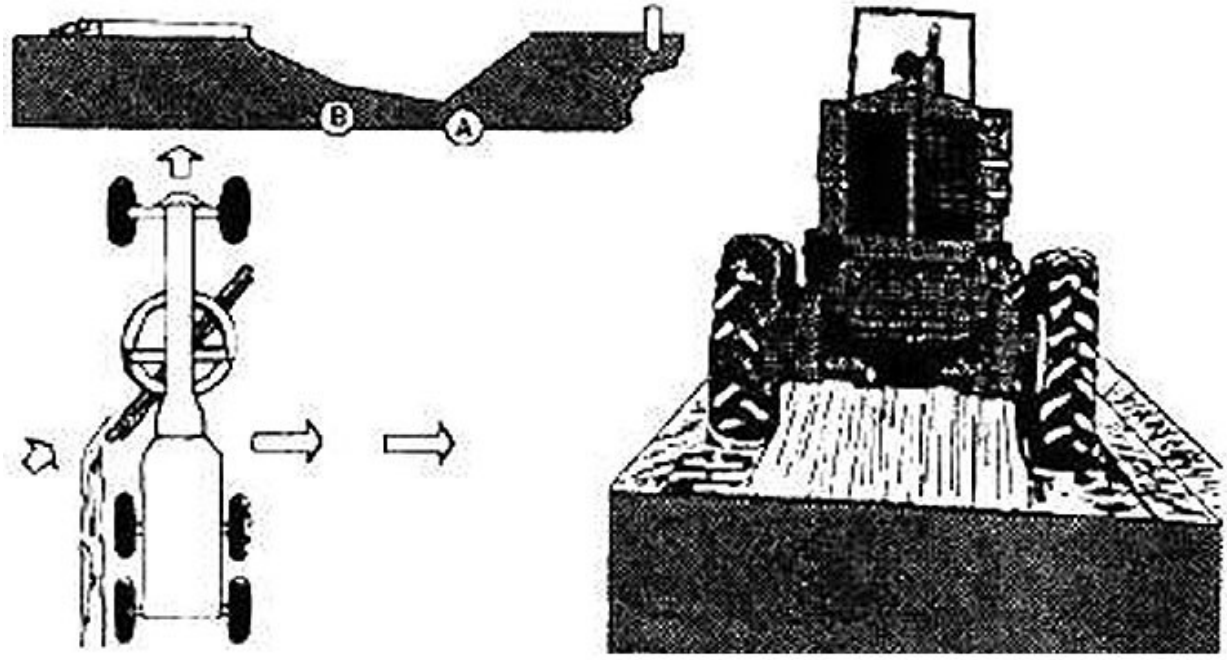


Figure 1–37. Grader construction.

Letter	Component	Purpose
A	Lift cylinders	Used as their name implies. Allows you to raise or lower the moldboard assembly by hydraulics. Located on each side of the grader.
B	Saddle	Provides support for the lift cylinders.
C	Center-shift cylinder	Allows you to shift the moldboard assembly from side to side.
D	Main frame	Just like an automobile, the grader must have a main frame to support all of its components.
E	Scarifier	Used like a ripper. Adds to the versatility and productivity of the machine. You use it to loosen hardened earth before you use the blade.
F	Drawbar	Works with the side-shift cylinder to shift the moldboard assembly side to
G	Circle	Used to rotate the moldboard at different angles to complete various jobs.
H	Cutting edges/end bits	Attaches to the moldboard. It is made of high-tempered steel to resist wear. It is what you might call the “business end” of the grader.
I	Moldboard	The part that moves the material (dirt, gravel, snow, and so forth). When traveling, rotate (circle) the moldboard so it’s not extended beyond the tires.

Controls

Let’s look at some standard controls that are inside a typical grader. Don’t let the myriad of controls confuse you. Someday you’ll be able to reach out without thinking and select the proper control for a certain blade movement. As you become familiar with these controls, your accuracy and proficiency will increase immensely.

There are typically nine control levers on a grader. There could be more or less depending on the type of grader and control configurations. The most common controls are as follows:

- Center shift lever.
- Wheel lean lever.
- Right/left frame steer lever (articulation).
- Left lift cylinder lever.
- Right lift cylinder lever.
- Circle side-shift lock.
- Blade pitch lever.
- Circle rotation.
- Scarifier.

NOTE: There may also be a lever for a scarifier (on the front) or ripper (on the rear) located on the control pack, or on an auxiliary lever located nearby.

Associate the lever with the component of the same name. This will give you a mental picture of that operation. When operating a grader, use the RIGHT FRAME steer lever or the LEFT FRAME steer lever for articulated steering. Articulated steering gives you a variety of positions for the blade, and lets you place the tractor tires on firm ground, which aids in accuracy while grading. Articulated steering when used in conjunction with the wheel lean, can cut your turning radius considerably.

SAFETY TIPS: Be careful when using a grader. With the blade angled while using the articulated steering, it is possible to run the blade into your own rear tire if you are not paying attention to blade position. If you want to fully articulate, make sure your blade is outside of your rear drive wheel.

Some graders have hydraulically controlled locking pins for the articulated steering. If you try to articulate before unlocking these pins, you could cause considerable damage to the pins or to the hydraulics. If there are no pins, you must pay careful attention to the articulation gauge to ensure the

machine is tracking straight ahead when needed (transporting or driving the machine down the road). Accelerated tire wear could occur if the machine stays articulated while driving.

NEVER reach through the steering wheel for one of the controls. You could hit a hole with one of the front wheels, causing the steering wheel to spin. With your hand or arm through it, you could end up with a sore and bruised wrist, and possibly a broken one. Always reach over or around the steering wheel for a control—never through it.

Grader operations-manipulating the blade

Reflect back to the controls for a minute. As you can imagine, you can adjust the grader moldboard in a variety of ways. Actual adjustment of course, depends on the job and the material handled. Jobsite conditions determine exactly how you set the moldboard. You'll find that the moldboard is very responsive. You can raise and lower it as little as a fraction of an inch to adjust to the grade being finished, or set it at any angle to the machine frame.

Two terms with which you must become very familiar are the *heel* and the *toe* of the moldboard. We define the characteristics of heel and toe configurations when the moldboard is angled, so that one end is ahead of the other. The toe of the moldboard is the leading end; the heel is the trailing end (fig. 1–38). Remember your toe goes before your heel. When you turn the moldboard so that the toe is to your left, earth spills off the heel, which is to your right. When the toe of the moldboard is to your right, the earth spills off the heel, which is to your left.

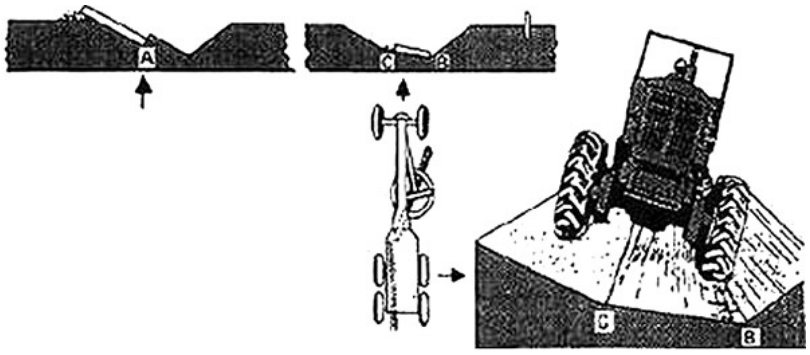


Figure 1–38. Moldboard heel and toe.

Position the blade

At this point, let's see how earth behaves when it encounters the moving moldboard set at different angles. First, with the moldboard straight across the circle (right angle to the frame is 90°), earth drifts straight ahead of the moldboard. We call this configuration "center windrowing" or "dozing."

The more you increase the angle of the moldboard, the more earth will spill off the heel. With your moldboard sharply angled, you can make a deeper cut. As the moldboard angle decreases, a greater amount of the material is drifted straight ahead, so less spills off the heel of the moldboard.

Lower or raise the ends

You can also lower or raise either end (right and left lift cylinders) of the moldboard. You regulate the depth of your cut by raising and lowering the toe of the moldboard. By raising and lowering the heel of the moldboard, you can either cast the material being worked into windrows or spread it evenly.

When you raise the heel of the moldboard, the material spills out underneath and is spread along the surface by the forward motion of the moldboard. By lowering the heel of the moldboard, you can control the amount of material spilling out under the heel, from very little to none. All the material cut is spilled off the heel and forms a windrow.

Here's one point you need to remember about the moldboard; when you raise or lower one side, the other side does the opposite. For example, when you raise the toe without adjusting the heel, the heel drops down slightly and begins to cut. Be sure to concentrate on both sides of the blade when operating a grader.

When you start to work with the grader, remember that it is not a productive earth-moving machine. You may have to make several passes up and down a road to cut as little as half an inch. Your job is to make the grade exactly right.

You can raise or lower the ends of the blade independently or together. You can position the blade perpendicular to the line of travel, parallel to it, or at any angle in-between. You can shift it to the side and into a nearly vertical position. Figure 1–39 shows the blade in several positions.

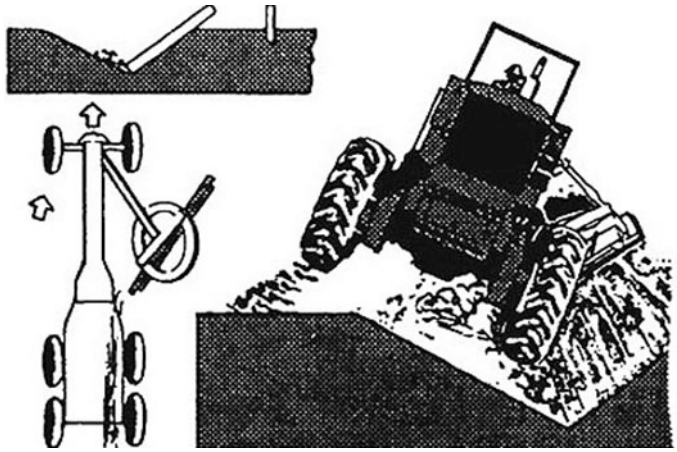


Figure 1–39. Grader blade positions.

Change the blade pitch

In addition to changing blade positions, you can also change the pitch of the blade in relation to vertical (fig. 1–40). Use the pitch adjustment on the moldboard to change the pitch on the cutting edge, thereby producing a cutting or dragging action, whichever you need. Ordinarily, you keep the blade near the center of the pitch adjustment (vertical) so that the top of the blade is directly over the cutting edge. Increasing the lean forward decreases the cutting ability of the blade. In this PITCH position, the blade tends to ride over material rather than cut it. Also, in this position the blade has less chances of catching on solid obstructions. Use this forward pitch position when making light rapid passes and blending materials. When leaned to the rear, the blade cuts readily but tends to let the material spill back over the blade when the cut is deep.

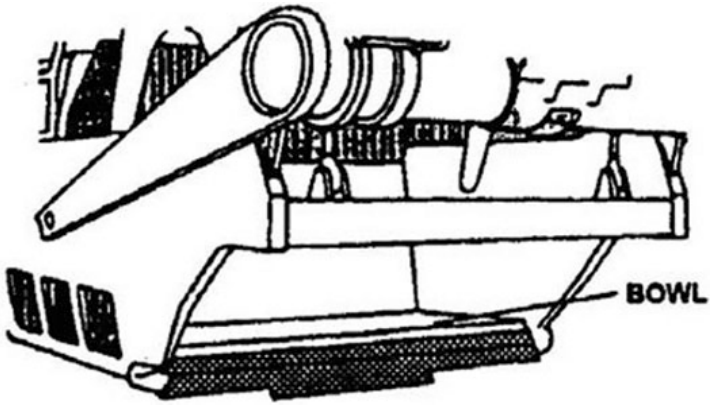


Figure 1–40. Grader blade pitch.

Functions and operating characteristics of a scarifier and ripper

We've already mentioned the use of scarifiers and rippers. To review, we use them on grading jobs where the material is too hard for the grader to handle. Their function is to break up or loosen hard material, so that the grader blade can do its job. Thus, the scarifier and ripper enable the grader to perform work that could not be done without these attachments.

The advantage of using a scarifier is that it can loosen material ahead of the machine, which can then be graded in the same pass. A disadvantage to a scarifier is that it is relatively weak when compared to a ripper and cannot handle extremely hard material.

Characteristics of a scarifier

The scarifier's teeth consist of slender shanks with replaceable caps (bits). They are set in either a V-shaped bar that is narrower than the grader or in a wider straight bar. The scarifier assembly mounted on the front of the grader typically has up to eleven teeth and is raised and lowered by a hydraulic cylinder (fig. 1–41). You secure each tooth with a locking wedge. To remove the teeth, you simply remove the locking wedge. You can also adjust the teeth to cut to different depths depending on the grader, typically up to 12 inches.

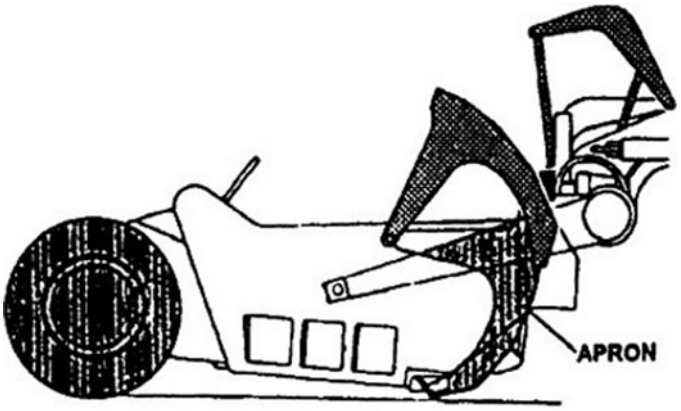


Figure 1–41. Front-mounted scarifier.

Another way to aid scarifier operations is by adjusting the pitch. For example, with the top of the scarifier pitched to the rear, you can apply a lifting and tearing action to the material being loosened. You use this position when breaking up asphalt pavement. Use different adjustments depending on the material and the action desired on the material.

Operating a scarifier

In scarifying, you always penetrate the material with the teeth. Do not allow the teeth to drag along on the top of the surface as this causes undue wear on the points. To break up material, place the transmission in a low forward gear, lower the teeth for a firm grip into the material to be loosened, and work the teeth as deep as permitted by the job and available power. Operate the scarifier in a straight line, not while turning.

Extremely hard surfaces require the use of fewer teeth. Accordingly, it may be necessary to remove teeth from the scarifier assembly; however, you must exercise great care when removing teeth because the remaining teeth carry the entire load of the operation. Removing teeth greatly increases the danger of breakage. If you must remove teeth due to material conditions, start with the center tooth and remove every other tooth. Removal of the teeth in this manner balances the scarifier and distributes the load evenly. If you remove more than five teeth, the force may shear off the remaining teeth.

Characteristics of a ripper

The advantage of a ripper is its superior strength and its ability to handle extremely hard material (fig. 1–42). The machine's power and traction may be the deciding factor in the material it can break up.

A disadvantage to the rear-mounted ripper is that the machine cannot grade the material in the same pass. The grader needs to pull out of the pass and maneuver back the start of the pass to grade the material. The process takes longer which could be a hindrance depending on the task. Also, the ripper adds length to the machine, making it awkward to maneuver in close quarters.

Ripper frames are usually mounted with five teeth. You determine tooth usage by the type of material being worked. In light soil, you can use all five teeth; in hard materials, reduce the number.

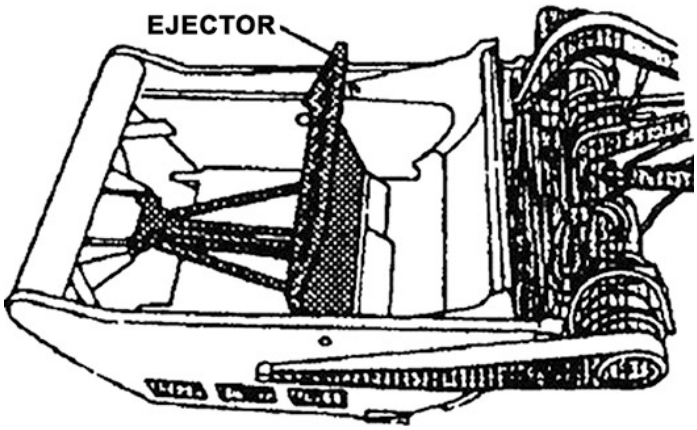


Figure 1–42. Rear-mounted ripper.

Operating a ripper

To carry out ripper work, lower the teeth until they make contact with the ground. Be careful not to lower the teeth too much because that will raise the grader's rear end causing loss of traction. First, place the grader transmission in a forward low gear. Then, with the grader moving ahead, lower the teeth into the ground to a depth that the grader can work without spinning the tires. When you use the ripper for breaking pavement, work the teeth under the pavement, and raise the ripper as you move forward. When you operate the ripper attachment, rip the material in a straight line and down grade, rather than uphill. Once the old material is removed, you're ready to start the process of building a road, beginning with a drainage ditch.

Constructing a ditch with a grader

Constructing ditches, as with most construction work, varies with climatic and soil conditions. This section explains some important general procedures.

Making a ditch cut

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

Normally, you do ditching on the right side of the grader. The first cut to make is the marking cut. The marking cut is a three- to four-inch deep cut made with the toe of the blade. Position the toe of the blade in line with the outside edge of the right front tire. For cutting, you adjust the pitch of the blade halfway until the top and bottom edges of the moldboard are aligned perpendicular to the ground. The marking cut is a technique we use for easier grader control and straighter ditches.

After making the marking cut, position the blade at about a 45 degree angle to perform an efficient ditch cut (fig. 1–43). Position the toe (leading edge) of the blade in line with the outside edge of the lead tire, while raising the heel (following edge) of the blade to allow the windrow to form inside the rear wheels (fig. 1–44).

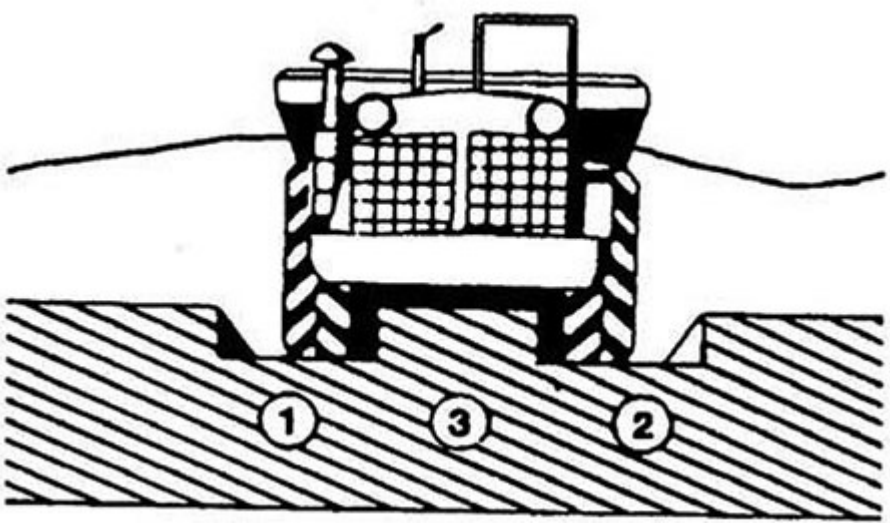


Figure 1–43. 45-degree position of the blade.

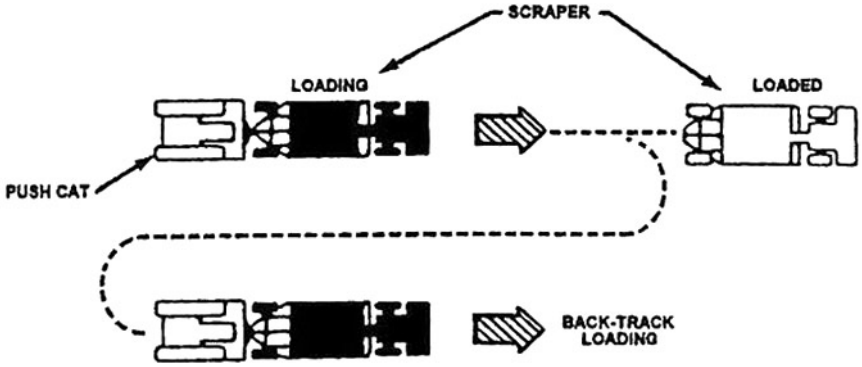


Figure 1–44. Ditch cut.

NOTE: Do not forget to lean the top of the front wheels in the direction of the flow of the cut material. When cutting, the machine tends to "pull" to the side of the leading edge (toe) if the cut is too deep or there is a lot of material being moved at once. By leaning the wheels in the opposite direction (to the heel side) this pull is somewhat counteracted. Also, try and take less of a bite to alleviate the pull.

At the end of each ditch cut, feather the material towards the middle of the road away from the ditching operation. This task is called *shoulder pickup*. To move the windrow away from the ditch, position the grader in the wide side reach (fig. 1–45). Position the heel to allow the windrow to be side cast inside the rear tandem tires. The purpose of the shoulder pickup is to move the windrow away from the foreslope of the ditch.

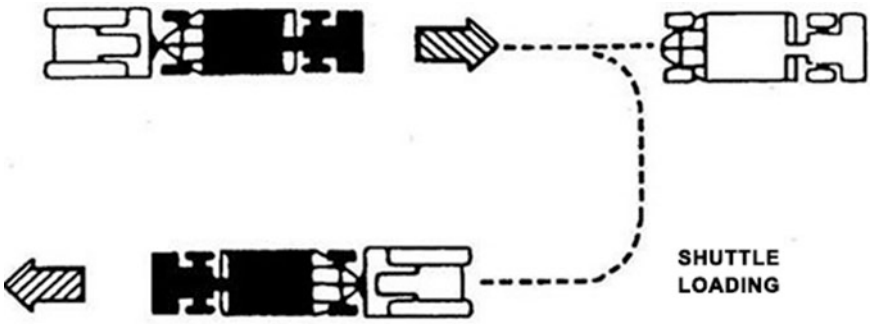


Figure 1–45. Shoulder pickup.

The next pass to make is the spreading pass (fig. 1–46). Position the blade and circle under the grader frame. While the grader straddles the windrow, place the toe of the blade inside the front tire, and then position the heel to side cast the material outside the rear tandem 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 you achieve the desired depth of the ditch.

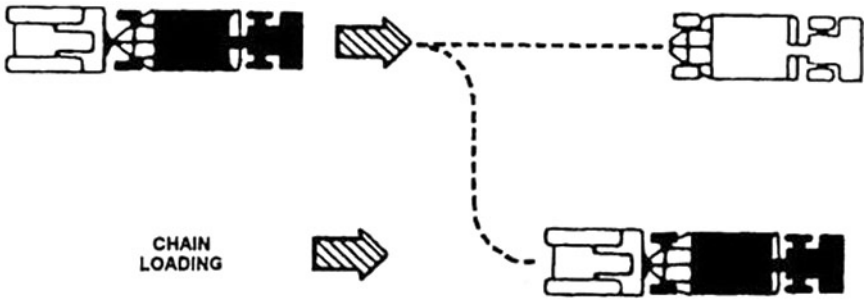


Figure 1–46. Spreading pass.

When the backslope of the ditch needs to be cut, position the circle and the blade with the heel resting at the bottom of the foreslope. This allows the material to flow inside the right rear tandem tire. The toe of the blade should be forward toward the right front tire. Lean the top of the wheels toward the backslope.

Making a flat-bottom ditch cut

At some time you may be required to construct a flat-bottomed ditch. Begin by starting at the foreslope of the original V-ditch (fig. 1–47, view A). Use this ditch-cutting procedure to cut another V-ditch. After you make the V-ditch, the next step is to make a flat cut in the bottom of the ditch by placing the complete length of the blade in the ditch. Position the toe at the base of the backslope (fig. 1–38, view B), and position the heel to side cast the windrow inside the rear tandem tires (fig. 1–38, view 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.

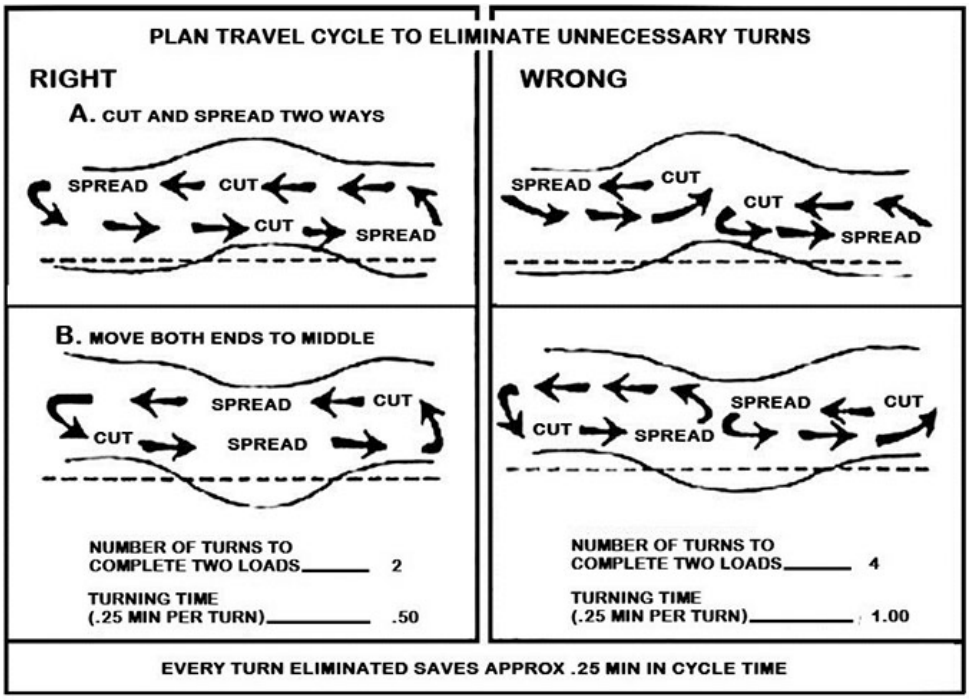


Figure 1–47. Flat-bottom ditch cut.

Leveling

Leveling an area is the process of cutting high spots and filling low spots. With the blade set at an angle, you can use the grader to level off irregular surfaces. You can complete this by lowering the blade just enough to cut the high spots. This in return, leaves a sufficient amount of cut material in front of the blade. You can then use this cut material to fill low spots. The forward and sideward movement of the loosened material also aids in distributing it effectively.

If you leave a windrow at the trailing edge of the blade, you can pick it up on the next pass. You can make a lighter cut on the final pass. On the final pass, lift the trailing edge of the blade high enough to allow the surplus material to go under the blade rather than around it. This avoids leaving a small windrow.

Under favorable conditions, you can use this type of leveling to produce a smooth surface; however, the material used to fill the low areas is likely to settle or be compressed below the cut sections. To reduce the chances of this settling, make a series of cuts across the area to reach the bottom of the low spots. You can then take the material from the windrow or other loosened material and spread it back evenly over the area. Using this method makes it easier to get a smooth surface. This is because working with a full blade of loosened material gives you a more uniformed distribution and allows the surface to remain smooth after settling or rolling. Be sure you do not pile windrows in front of the rear wheels, as this affects traction and grading accuracy.

Sloping

After you cut the ditch to the desired depth and remove the windrows, you must slope the bank. This not only adds to the appearance of the road but also prevents the bank from crumbling and filling the ditch. You see the operator positioning the moldboard assembly to slope the bank (fig. 1–48).

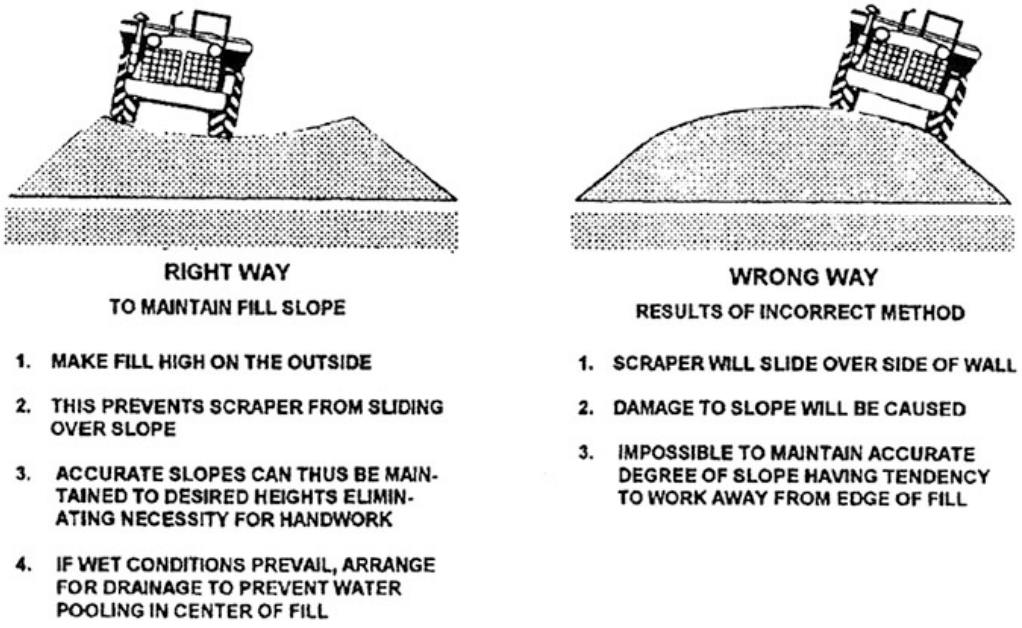


Figure 1–48. Bank sloping.

When the backslope of the ditch needs to be cut, position the circle and the blade with the heel resting at the bottom of the foreslope. This allows the material to flow inside the right rear tandem tires. Keep the toe of the blade forward toward the right front tire. Lean the top of the wheels toward the backslope.

If a ditch is to have a plain V-bottom, perform a clean-up pass on the foreslope to remove the material from the backslope cut. Move the windrowed material from one shoulder to the other. This fills the low spots and makes a level surface. After the foreslope is clean, perform a shoulder pickup and a spreading pass to finish the ditching operation.

Crowning

The final step in road grading is usually the building of a crown or downward slope from the centerline of the road toward the shoulders. The purpose of the crown is to provide drainage from the centerline toward the road shoulders. For unpaved surfaces (dirt roads), a slope of four–six percent should be adequate. This represents approximately half inch to three-fourths inch fall per horizontal foot, the entire width of the lane, usually 10 feet. For surfaces which will be paved, establish a slope of approximately two percent which represents one-fourth inch fall for every foot.

To start the crown (or to reestablish a crown), angle the blade to 45 degrees with the toe on the shoulder. Most of the material that made up the crown ends up at the shoulder through vehicle wear, weather, and gravity. Start the cut raising the heel slightly as material starts to flow. Keep the heel raised approximately three-fourths to one inch off the original surface, and lower it (back to level) as the machine rides up onto the newly placed material (if you don't lower the heel back down, your slope may be off). Try and keep material in front of the blade at all times as this will ensure you fill any low spots and will also create a windrow near the centerline of the road. Regulate your depth by raising and lowering the toe. Once complete with this first pass, turn around and head back down the road on the other side doing the exact same thing. Now you have two windrows near the centerline. The third pass will consist of riding alongside the centerline (never straddle the centerline!) picking up one of the windrows and casting it over onto the other side. In this way, we divide the road into two distinctive zones. On the fourth pass, you will set your blade onto the newly established grade (made in the first and second passes) with the toe over the centerline. You are merely distributing the windrow left on the previous pass and establishing a sharp crown. Drift the material under the blade, and try to feather it out as best as possible without raising the elevation.

The final step is to compact the entire road from shoulder to shoulder without straddling the centerline. Again, treat the two sides of the road as two separate projects. If needed, water the road to raise the moisture content.

When grading you will not always be able to obtain a full-visual view of a project site from the operator's seat. For this reason, stop and climb off the grader periodically to take a visual look at the work area to determine work progress and areas that need further attention.

Blue-topping

This phase of the grading operation consists of a final finish grade, which is a fine cut or fill of a surface to get the final desired elevation. Blue-topping, so called because of the blue-topped hub stakes used to show finished elevation, takes time and patience even for experienced operators.

When performing blue-topping operations, make sure the grader cutting edges are not worn, the tires are the same size with the correct air pressure, and the tires are pointed in the right direction (for directional tread patterns). Adjust the blade forward (tilt) to scrape instead of cut so you can see the bottom of the blade. Rolling the blade forward also allows the operator a better view of the "whiskers" attached to the blue top stakes when the blade rides over top of them. When you see the whiskers, you are at the proper elevation. It is also best to have the surface compacted before you begin finish grading. It is easier to cut one-half to one inch than it is to fill an entire area.

Before making any cuts on a project, review the project's blue-topped hub stakes to note their location and how much you have to cut. Remember, hub stakes are driven into the ground until the top is at the exact elevation of the finished grade (determined by the surveying crew).

Dividing the project into sections and working one section at a time is a good technique to use when blue- topping. After you grade the first section, you'll have a reference point to start from to grade the other sections. As with any earth-moving 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 must run over. Windrow the material to the end or off the section and have a loader pick it up and move it away from the grader. If there is room, you can windrow the excess material off the project for later removal.

When cutting, be extremely careful when dragging 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, a worker on the ground or an engineering assistant should clean off the top of the stakes so you can see them for your next pass.

Use proper lubrication and fuel

Lubrication reduces friction between moving parts. Friction is harmful because it wears out parts and generates heat. Lubrication is not confined to the use of grease. If the grader engine is not filled to the proper oil level, it's not going to last very long. It also needs proper lubrication for the internal parts to move smoothly with each other. For information on the type, amount, and viscosity of lubricants, check the lubrication charts (LC) or a lubrication guide (LG) for a particular piece of equipment. The LCs and the LGs are usually found on the piece of equipment near a service area. If the LC or LG is not found on the equipment, then look in the applicable TO or owner's manual.

Graders in the AF inventory have diesel-operated engines; therefore, proper fuel selection is a must. Always ensure that fuel tanks in the equipment yard are properly marked. Most wheeled equipment can be driven to the fuel station to be fueled. Be sure that the operators of your section understand the importance of using the proper fuel. Always ensure the grader has at least three-quarters or more fuel in the tank at the end of each shift.

Change cutting edges and end bits

As we mentioned earlier, the earth-moving part of the grader consists of three components: moldboard, cutting edge, and end bits. The cutting edge on the grader we call a blade, and the blade base we call a moldboard. The moldboard is the large earth-moving part of the grader. The moldboards itself is protected from damage and wear created in the cutting action by the cutting edges and end bits.

Changing the cutting edges and end bits on a grader is part of operator maintenance. The grader's cutting edges are the most common area subject to excessive wear. It is your responsibility to know how to do this critical task and to ensure they don't wear down into the moldboard.

When changing the cutting edges/end bits, *never*, under any circumstances, do it with the engine running. Even though the blade will only come down under the power of the engine, always block the moldboard for added safety. Constantly, be aware of safety issues and conscious when working with or around construction equipment. Don't take any chances.

Before removing the cutting edges, be prepared to clean the bolt threads because they will probably be dirty and rusty. Use penetrating oil on the bolt threads to loosen the rust and clean the threads with a wire brush. Use the proper size socket and remove the nuts. Remove the bolts and blade. On many graders, you can reuse the cutting edge by reversing it. A large punch to align the bolt holes is especially helpful when you are aligning them onto the moldboard. Always use the proper tools when changing cutting edges.

Check the tires

Check grader tires for proper inflation at least every months and whenever pressure is questionable. Over-inflated tires can cause the grader to gallop or bounce and give you an uncomfortable ride. You can reduce this effect by deflating the tires slightly, but don't let too much out. When you do this, make sure all six tires are at the same pressure. During your walk-around inspection of the grader, check the tires for any signs of deterioration or cuts. Repair or replace badly cut or worn tires immediately.

When checking the tires, notice the direction of the tread on the rear tires, and then look at the front tires. The front and rear tire treads should be opposite. The reason for this is that the rear wheels are power driven, and the point of the V-tread meeting the ground first gives better traction. The front wheels are not powered. The point of the V-tread meeting the ground last makes the front tires wear longer.

At some point, you'll undoubtedly have a flat tire on your grader and have to take the tire off and put it back on. When this happens, be sure you put the tire back on so the tread turns in the proper direction.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

205. Bulldozers

1. What AF Form must you sign after you complete a preinspection?

2. What makes the dozer's transmission controls simple to operate?

3. How can you increase or reduce speed in a bulldozer?

4. When you are ready to move the dozer, how do you position the blade?

5. How do you apply down pressure to the rear-mounted ripper?

6. What disadvantage do some dozers have with rear-mounted rippers?

7. What is the best way to operate the dozer while ripping?

8. What four steps do you complete to start a cut?

9. What happens if you raise and lower the blade two or three inches when making a cut?

10. How do you compensate for the up-and-down movement of the front of the dozer?

11. What bulldozing method uses spillage of previous cuts to keep the blade full?

12. Briefly, how do you remove small trees and brush?

13. What safety aspect must you watch out for when removing trees?

14. How do you remove a tree that you cannot push over?

15. Why do you not cut the roots on the side in which the tree will fall?

16. When removing rocks, what is the next step after you work one corner of the blade under the rock?

17. When making a side-hill cut, how can you increase dozer productivity?

18. What is the proper procedure for starting a side-hill cut?

19. In what position do you place the blade to cut V-shaped ditches?

20. In backfilling culverts, when is it okay for the dozer to cross the culvert?

21. Where do you start finishing side slopes when working diagonally to the slope?

22. When backing the dozer off a stockpile, why do you not raise the blade?

23. Why are angle dozers not recommended for use as pushers?

24. What must the slope of a berm be?

25. What is the recommended height of a berm?

26. With which type of soil can greater slopes of a berm be sustained?

27. What type of winching operation involves securing the dozer winch line to a structure sufficient enough to hold the dozer on the slope?

28. What is the advantage of bringing a water truck to the job site to clean a dozer?

29. When do you refuel your dozer and why?

30. If the dozer track is too tight, how do you loosen it?

31. What types of air filters can you find on dozers?

32. Why is it very important to change the cutting edges on a dozer?

206. Graders

1. What type of inspection must you complete before operating a grader?

2. What is the function of the scarifier?

3. What factor determines exactly how you set the moldboard?

4. How do you increase the amount of earth you spill off the heel?

5. Why is it important to concentrate on both ends of the moldboard?

6. What happens when you set the blade pitch in the FORWARD position?

7. What is a disadvantage to using a scarifier?

8. Why must you exercise extreme care when removing some of the teeth from the scarifier assembly?

9. What are two disadvantages of the ripper?

10. Which way do you lean the front tires when constructing a ditch?

11. What is the purpose of performing a shoulder pickup?

12. What can you do to reduce the chance of material settling?

13. What happens if you pile up windrows in front of the rear wheels?

14. What is the purpose of a crown in the road?

15. What is a good technique to use when blue topping? Explain why.

16. What is the purpose of lubrication?

17. Where can you find information on proper lubrication?

18. What must you *never* do and *always* do when changing cutting edges?

19. Why should the point of the V-tread on the rear tires touch the ground first?

Answers to Self-Test Questions

201

1. (1) PTO-control.
   (2) Bed control valve.
2. Two Personnel: The dump truck operator will be the safety spotter also, and the forklift operator.
3. Leaving the tailgate open, while driving, could cause your load to spill, creating a hazard.
4. (1) Stop the truck where you want to start the spread.
   (2) Place the dump control levers in the proper position.
   (3) Raise the bed about a foot.
   (4) Trip the tailgate as you drive forward in low gear.
5. Prevents the pintle hook from coming open when the vehicle is transporting a piece of equipment.

202

1. To determine what maintenance, if any, is needed and to ensure the loader is ready for any job.
2. The operator.
3. (1) Clamshell.
   (2) Dozer.
   (3) Scraper.
   (4) Scoop-shovel.
4. To roll the bucket forward and backward.
5. The clamshell closes.
6. Direction control and range control.
7. When performing loading and excavating work.
8. When it works on flat, smooth-surfaced areas with the proper space to maneuver.
9. To prevent injury to the operator if a large object should crush the truck’s cab during loading operations.
10. Lowered, level, and flat on the ground.
11. To pick up small piles of materials. Also preferred when handling sticky material.
12. Loosen the material first by using a rooter or ripper.
13. Dozer and back dragging.
14. Build your stockpile in layers to make sure it maintains a uniform gradation.
15. Shut the loader engine OFF.
16. Pull back on the hydraulic levers (lift, tilt, clamshell) toward you, then push the levers away from you.
17. You may need to wiggle the attachment.

203

1. Move the steering to control a smaller amount.
2. To move forward, push both operating controls forward. To reverse, use both operating levers toward you.
3. By a mode switch located on the instrument panel in the operator’s cab.
4. Downward and slightly toward the loader.
5. When the bucket is full.
6. Wheel saw.

204

1. (1) The tractor.
   (2) The scraper assembly.
2. (1) Bowl.
   (2) Apron.

(3) Ejector.

3. For deeper penetration.
4. Typically 300 feet.
5. (1) Loading.
   (2) Hauling.
   (3) Spreading/unloading.
   (4) Returning.
6. Backtrack loading.
7. To spread loose material piled up in front of the cutting edge, resulting in a smooth cut and allowing the following scraper to maintain speed.
8. At the start of the fill.
9. By bringing the tilt floor or tailgate forward 12 inches at a time. After each forward movement, return the tilt floor or ejector approximately six inches.
10. (1) You can travel at higher speeds.
    (2) Increase safety.
    (3) Reduces operator fatigue and equipment wear.
11. It reduces the chance of upsetting or bouncing the equipment.
12. (1) Do work quicker.
    (2) Accelerate faster.
    (3) Operate more safely.

205

1. AF Form 1800.
2. The dozer is equipped with a hydrostatic transmission so one lever controls both the speed and direction of travel.
3. Pull the lever back to increase speed and push it forward to reduce speed.
4. Raise the blade just high enough to clear any obstructions.
5. By working the hydraulic ram between the dozer and the toolbar, thus using a portion of the dozer weight to increase down pressure.
6. The rear-mounted ripper is mounted in place of a drawbar and the dozer cannot be used to tow attachments.
7. In low-range or slow-track speed, with the maximum number of teeth.
8. (1) Shift the speed and direction-control lever to the FORWARD position, and move forward.
   (2) Lower blade into ground until it starts cutting.
   (3) When dozer starts pulling hard, raise the blade in small increments.
   (4) When blade is full, raise it to ground level and push the material to the desired point.
9. The blade will cut an uneven surface on which the dozer must travel.
10. When the front of the dozer noses up, lower the blade; when the front of the dozer noses down, raise the blade.
11. Slot dozing.
12. Lower the blade just enough to cut the roots and move forward.
13. Watch for dead limbs falling out of trees when pushing them over.
14. Make side cuts to cut the root system.
15. Because the roots help prevent the tree from falling on you.
16. Move forward and raise the blade to roll the rock out.
17. By working the dozer from the top of the proposed road downward.
18. Start the cut by working straight down the hill with short passes.
19. Angled and tilted.

20. When there is at least 12 inches of material on top of the culvert.
21. At the bottom, working diagonally up the slope.
22. It puts extra weight on the front idlers and causes greater track penetration.
23. The blades are more lightly constructed and may become bent or severely damaged.
24. 1:1 or be sloped at the angle of repose of the soil.
25. At least equal to the height of the structure or as high as practical.
26. Cohesive soils.
27. Moving.
28. Saves time of loading and hauling the dozer to a wash rack.
29. At the end of the workday if the tank is less than three-fourths full. It cuts down on condensation and assures that the dozer is ready for any emergency.
30. By removing plug at front of the track adjuster, loosening the valve in the track adjuster to let grease out, and driving the machine forward and backward several times to loosen the track.
31. Primary (outer) and secondary (inner) elements.
32. The cutting edges could wear into the blade bases, which are very expensive to rebuild or replace.

206

1. Preinspection.
2. Loosen harden earth, like a ripper.
3. On-job conditions.
4. By increasing the angle of the moldboard.
5. If you raise the toe without adjusting the heel, the heel will drop down and begin to cut.
6. The blade tends to ride over material rather than cut it.
7. It is relatively weak when compared to a ripper and cannot handle extremely hard material.
8. Because when you remove teeth, it concentrates the entire load on the remaining teeth and greatly increases the danger of breakage.
9. (1) You cannot grade the broken-up ground on the same pass.
   (2) Adds to the length of the machine, limiting maneuverability.
10. With the top of the wheels leaning in the direction of the flow of the cut material.
11. To move the windrow away from the foreslope of the ditch.
12. Make a series of cuts across the area to reach the bottom of the low spots.
13. Traction and grading accuracy will be diminished.
14. To provide drainage from the centerline toward the shoulders.
15. Divide the project into sections, working one section at a time. It gives you a level starting point and a reference point to start from to grade the other sections.
16. To reduce friction between moving parts.
17. Lube charts and a lube guide, either on the machine or in the proper TO or operator’s manual.
18. Never leave the engine running when changing cutting edges. Also, always follow other safety precautions, and have the proper tools.
19. The point meeting the ground first gives better traction.

Complete the unit review exercises before going to the next unit.

Unit Review Exercises

Note to Student: Consider all choices carefully, select the *best* answer to each question, and *circle* the corresponding letter. When you have completed all unit review exercises, transfer your answers to the Field-Scoring Answer Sheet.

Do not return your answer sheet to the Air Force Career Development Academy (AFCDA).

1. (201) If you choose to spread materials in layers, you should stop the truck where you want to start the spread, position the dump control levers, and
   a. raise the bed about two feet.
   b. raise the bed about three feet.
   c. raise the bed enough to break the material free.
   d. ensure the bed is all the way down and chained.

2. (202) When properly equipped, a front-end loader can perform tasks associated with each operation task *except*
   a. dozer jobs.
   b. scraper jobs.
   c. trailer operations.
   d. clamshell operations.

3. (202) What defect are you looking for when inspecting loader buckets without teeth?
   a. Wear of the cutting edges and end bits.
   b. Wear of the side plates.
   c. Scratches in the paint.
   d. Broken welds.

4. (202) What function can the front-end loader *not* perform when equipped with a multipurpose bucket?
   a. Dozer.
   b. Scraper.
   c. Dragline.
   d. Clamshell.

5. (202) What front-end loader bucket control is used to raise and lower the bucket?
   a. Lift control lever.
   b. Clam control lever.
   c. Bucket control lever.
   d. Transmission control lever.

6. (202) Which front-end loader control regulates the transmission speed?
   a. Clam control lever.
   b. Range control lever.
   c. Direction control lever.
   d. Clutch cutout control lever.

7. (202) How should you backfill a trench when using a front-end loader with a narrow bucket?
   a. Raise the bucket about two inches off the ground.
   b. Move the loader straight into the material.
   c. Move the loader rapidly into the material.
   d. Backfill the area from an angle.

8. (202) What must you do before performing any maintenance action on a front-end loader?
   a. Put the transmission in neutral.
   b. Remove all fuel from the fuel system.
   c. Disconnect and cap the hydraulic system.
   d. Turn the loader off and set the parking brake.

9. (203) What advantage does a compact track loader (CLT) have over a standard front-end loader?
   a. It does not need to be hauled to the job site.
   b. Machine controls react quicker.
   c. Can operate in a smaller area.
   d. It consumes less fuel.

10. (203) How do you spin a compact track loader (CTL) around within its own body length?
    a. Move bucket controls in opposite directions.
    b. Move the travel controls in opposite directions.
    c. Engage auxiliary control switch and move travel controls.
    d. Engage auxiliary control switch and move bucket controls.

11. (203) If you release the skid-steer loader travel controls levers,
    a. the engine will die.
    b. equipment will stop moving.
    c. engine will return to an idle speed.
    d. equipment will automatically resume a forward momentum.

12. (203) You ensure good sweeping action and avoid bystanders or damaging equipment when using the skid-steer loader with the sweeper attachment by using a broom pattern
    a. two to three feet wide.
    b. one to two yards wide.
    c. three to four inches wide.
    d. two to three inches wide.

13. (203) How are *most* attachments controlled once the auxiliary hydraulics are activated in the compact track loader (CTL)?
    a. Toggle switches on the travel controls.
    b. Toggle switches located on the dash board.
    c. Hydraulic levers located to the left of the driver’s seat.
    d. Hydraulic levers located to the right of the driver’s seat.

14. (204) What distance in feet is the efficient operating range of a scraper?
    a. 200.
    b. 300.
    c. 400.
    d. 500.

15. (204) What four phases of operation make up the work cycle in any scraper operation?
    a. Hauling, spreading, planning, and returning.
    b. Spreading, planning, loading, and returning.
    c. Loading, hauling, spreading, and returning.
    d. Planning, scraping, hauling, and returning.

16. (204) Generally, push-loaded scrapers should be loaded within a *maximum* distance of how many feet?
    a. 50.
    b. 75.
    c. 100.
    d. 150.

17. (204) When operating a scraper, at what speed should you enter the loading area?
    a. Controlled low-return speed.
    b. Controlled high-return speed.
    c. Slower speed than the pusher.
    d. Same speed as the pusher.

18. (204) When spreading material with scrapers, why should you route the scrapers so their tracks overlap?
    a. Maintain pumping.
    b. To promote compaction.
    c. To guarantee faster exit speeds.
    d. Ensure less tearing of the surface.

19. (204) When spreading materials with a scraper, you should make the fill high on the outside edges to
    a. assist in proper compaction.
    b. complete the compaction process.
    c. have proper drainage in the center of the fill.
    d. prevent the scraper from sliding over the edge.

20. (204) When using a scraper, you can save valuable time on short-radius turns by using
    a. a figure-eight cycle.
    b. the shuttle method.
    c. long-radius turns.
    d. circle returns.

21. (204) If the haul road on which you are operating a scraper is rough and no grader is available, you should
    a. travel at a slower return speed.
    b. travel at a higher return speed.
    c. lower the scraper bowl on the haul trip to level the road.
    d. lower the scraper bowl on the return trip to level the road.

22. (205) Why do you allow the crawler-type dozer engine to idle three to five minutes before shutdown?
    a. Prevent damage to the hydraulic pump.
    b. Prevent damage to the turbo charger.
    c. Increase water pump pressure.
    d. Decrease oil pump cavitations.

23. (205) The attachment of a rear-mounted ripper to a dozer does *not* seriously affect the
    a. dozer’s ability to stockpile material.
    b. maneuverability of the dozer.
    c. operator’s rear vision.
    d. weight of the dozer.

24. (205) What do you do if you are ripping material and your dozer continually lags or stalls?
    a. Increase the track speed.
    b. Decrease the track speed.
    c. Gradually raise the ripper.
    d. Reduce the number of teeth.

25. (205) You would use the side-by-side dozing method only for hauls of *at least*
    a. 50.
    b. 75.
    c. 100.
    d. 150.

26. (205) What dozing method are you performing when you use the spillage from the first few passes of a dozer to build windrows that hold the earth in front of the blade?
    a. Slot.
    b. Strip.
    c. Angle.
    d. Downhill.

27. (205) When removing a medium-sized tree with a dozer, what position do you place your dozer blade for initial contact with the tree?
    a. As high as it will go.
    b. On the surface of the ground.
    c. About one foot above the ground.
    d. Lowered into the ground as far as it takes to cut the roots.

28. (205) What must you do if your dozer *cannot* initially push over a large tree?
    a. Get a chain saw and cut the tree down.
    b. Cut the roots with the blade and push the tree over.
    c. Connect a chain between two dozers and pull the tree down.
    d. Back up 30 feet and run up against the trunk at a high speed.

29. (205) How far from the construction stakes do you line up your dozer when building a V-shaped ditch?
    a. One foot.
    b. Two feet.
    c. Three feet.
    d. Four feet.

30. (205) You gradually raise the blade at the end of the cut when constructing a stockpile with a dozer to
    a. make the cut even.
    b. allow for drainage.
    c. avoid creating an abrupt ridge.
    d. aid the dozer in getting out of the cut.

31. (205) What ratio is the minimum side slope ratio for berms?
    a. 1:1.
    b. 1:2.
    c. 2:1.
    d. 2:3.

32. (205) What two main elements cause erosion on a berm?
    a. Snow and ice.
    b. Roots and rocks.
    c. Weather and rodents.
    d. Sunlight and equipment traffic.

33. (205) How do you usually rate the power of a winch on a dozer?
    a. Weight of the dozer.
    b. Displacement of the motor.
    c. Size of the hydraulic pump.
    d. Maximum pull exerted on its line.

34. (205) Why do you clean the mud out of the tracks of your dozer?
    a. To keep the rollers from developing flat spots because they are unable to move.
    b. To make it safer to haul with a tractor trailer.
    c. The removal of mud is not required.
    d. To find lubrication points.

35. (206) What could happen when using articulated steering on a grader with the blade positioned at an acute angle?
    a. Blade lift capability is limited.
    b. Side shift capability is limited.
    c. Blade could run into the rear tire on turns.
    d. Excessive pressure is put on the lift cylinders.

36. (206) What component should you *never* reach through while operating a grader?
    a. Side window.
    b. Front window.
    c. Steering wheel.
    d. The control pack on the column.

37. (206) You regulate the depth of your cut with a grader by
    a. leaning the front wheels.
    b. articulating the grader frame.
    c. raising or lowering the toe of the moldboard.
    d. raising or lowering the heel of the moldboard.

38. (206) What type of action occurs when you pitch a grader scarifier to the rear?
    a. Planning.
    b. Tearing.
    c. Dragging.
    d. Spreading.

39. (206) What grading operation spreads material away from the ditching operation and toward the middle of the road?
    a. Shoulder pickup.
    b. A ditch cut.
    c. Crowning.
    d. Sloping.

40. (206) When cutting the back slope of a ditch with a grader, you position the circle and blade to allow the material to flow
    a. outside the right rear tandem tire.
    b. inside the right rear tandem tire.
    c. outside the right front tire.
    d. inside the right front tire.

41. (206) How can you avoid leaving an edge when making the final leveling pass with a grader?
    a. Lower the trailing edge of the blade.
    b. Lower the front edge of the blade.
    c. Lift the trailing edge of the blade.
    d. Raise the front edge of the blade.

42. (206) What stakes do you examine before making any finish-grading cuts on a project?
    a. Hub.
    b. Slope.
    c. Off-set.
    d. Centerline.

43. (206) Other than on the equipment itself, where can you find lube charts that pertain to a particular piece of equipment?
    a. Catalogs.
    b. Pamphlets.
    c. Brochures.
    d. Technical orders (TO).

Please read the unit menu for unit 2 and continue ➔

Unit 2. Material Handling Equipment

THE DEFINITION OF material handling equipment (MHE) is any equipment used in the movement, storage, control and protection of materials, goods and products throughout the process of manufacturing, distribution, consumption, and disposal. Most of the items included in this definition do not pertain to our field; however, the Occupational Safety and Health Administration (OSHA) specifically states that forklifts and cranes are MHE. We will also add tractor and trailer combinations into the broader definition as they go hand-in-hand during CE operations. This unit of instruction will specifically discuss these pieces of equipment as well as hauling cargo, rigging, and lifting as they logically fit within the purview of the unit. Let's begin with tractor-trailer combinations.

2–1. Tractor-Trailer Combinations

Truck-tractors and semitrailers are commonly referred to as tractors and trailers. So for simplicity, we'll use these terms. Tractors normally range in size from 5–20 tons which denotes their towing capacity. Each tractor has a data plate attached to the dashboard. Refer to this plate to determine the load capacity of the tractor. Trailers range from about 18 feet to 40 feet long and from 8 feet wide to 10 feet wide. There are several types of trailers, but the ones you're interested in are general cargo and equipment trailers. The major differences are that equipment trailers, which are commonly called lowboys, are lower and stronger. Lowboy deck heights are only about three feet high. No matter which type of trailer you are talking about, they both have data plates showing their specific load capacity.

The operation of tractors-trailers is a bit more complicated than for dump trucks, but this shouldn't present any problems. Careful study of the information we present in this section will make this task easier. As we go through the section, we'll look at the following basic topics—coupling and uncoupling a semitrailer and how to turn, back, slow, stop, and operate over the road with a tractor-trailer combination.

207. Inspection

Before operating the tractor and trailer combination (the tractor and trailer combination will be referred as just tractor-trailer), you must conduct a complete and thorough pretrip inspection. Because these vehicles are considered commercial and may be driven on interstate highways and other major roads, we will be discussing the proper way to inspect as presented by the Department of Transportation's (DOT) Commercial Drivers program.

Tractor pretrip inspection

As military members, we do not need to have a commercial driver's license; however, when we are sharing the road with other commercial drivers and the general public, we need to abide by the same principles of conduct.

As with other vehicles, obtain the vehicle package and ensure it has the appropriate AF Form 1800, Operator's Inspection Guide and Trouble Report (General-Purpose Vehicles); waiver card; fuel card or vehicle identification link (VIL) key (fuel key); and accident forms.

NOTE: The location of the components varies on different makes and models of truck-tractors. If the item requires inspection, service, or adjustment, check it in a logical sequence as you proceed around the truck. This inspection can be conducted on coupled (with a trailer) or uncoupled units. In addition to the items on the AF Form 1800, you are required to inspect those items unique to tractor-trailer combinations.

The purpose of the pretrip inspection is to ensure the vehicle is safe to drive. In the civilian world, you may have to *prove* this to inspectors and enforcement officers. The following pretrip inspection criteria are for guidance only. Within your unit, establish checklists or procedures to follow so that every individual inspects the same items, the same way, every time. This ensures that no individual will miss important items, which could lead to accidents.

Beginning the pretrip inspection

You begin the inspection by opening the engine compartment. You must inspect the engine compartment carefully for the following items:

- Leaks/hoses—Check for puddles of fluid, dripping fluids from components, and ensure hoses are firmly connected and not leaking.
- Oil level—The level must be above the fill line and within the operating range.
- Coolant level—Inspect the reservoir sight glass, or if there isn't one, remove the radiator cap (if the engine is not hot of course). Add coolant if necessary.
- Power steering—Make sure you know where it is and how to check for proper fluid level.
- Belts—There are several belts to check including, but not limited to: power steering, water pump, alternator, and air compressor. Check for adjustment (approximately ¾-inch play at the center), cracks, or frays.
- Steering components—Make a visual check of the components looking for leaks, missing parts, and general appearance. Bent or missing steering components are very dangerous.
- Suspension components—Look for obvious damaged, missing, or broken parts.
- Brakes—If something looks out of place or air is leaking, have maintenance take a look. A tell-tale sign of a leaking air line or fitting is a hissing sound.
- Wheels—Check the tires for wear, abrasion, bubbles, cuts, separations, and proper inflation. Check the rim for damage. Also, make sure the lugs are all there, tight, and not damaged. If equipped with hub oil seals, check them to make sure they are not leaking (and add oil if needed).
- Close and latch the hood then go to the front of the vehicle checking overall appearance paying particular attention to the lights. If they are dirty, clean them. If lenses are broken, replace them.

Move down the side of the vehicle and check

As you inspect the side of the vehicle, be sure you check the following:

- Side of the vehicle—Check overall condition for damage and make sure the doors open and close properly. Tug on the mirrors to make sure they are solidly mounted.
- Fuel tank—Make sure the tank is secured, straps are not broken, the cap is tight, and there are no leaks.
- Battery box—Make sure the batteries are secure, the connections are tight and there is no corrosion. Corrosion is a good indication of poor connection and may need replacement.
- Exhaust system—Make sure the exhaust is secure and there are no leaks (streaks of soot from joints or corrosion).
- Air/electric lines—Listen for air leaks and damage to the lines. Make sure the lines are not tangled, pinched, or dragging against tractor parts.
- Driveshaft—Make a visual inspection of the driveshaft paying particular attention to damage.
- Catwalk—If equipped, check the overall appearance and make sure it is solid, clear of objects, and secured to the tractor.
- Rear wheels—Check the rims, wheels, and lugs. Also, make a visual inspection between sets of dual wheels as debris can become lodged in between the tires.

Fifth wheel assembly

You will inspect the fifth wheel assembly by checking the following:

- Locking jaws—Check to ensure the locking jaws are fully closed around the kingpin (if the trailer is attached)
- Lower fifth wheel—Check for proper lubrication, and make sure it is securely fastened to the tractor's frame.
- Frame—Check for cracks, missing hardware, and overall appearance of the fifth wheel frame structure.
- Release lever—Make sure the lever is in the proper setting (closed if the trailer is attached) and that it is not bent.

Move around the rear of the vehicle and down the other side (if a trailer is not attached)

As you move around the rear of the vehicle check for the following:

- Mud flaps—Check the mud flaps to make sure they are secured and will not fall off. It is mandatory to have mud flaps, so replace them when necessary.
- Check—All components on the other side of the vehicle as you did earlier.

Trailer pretrip inspection

Now that you have inspected the tractor, you can now inspect the trailer. Inspect the trailer by checking the following:

- Trailer front—Check air and electrical connections looking for damage and air leaks. Check glad-hands to make sure they are tight and not leaking air. Make sure the electrical plug is firmly seated and locked in place.
- Compartments—Make sure load binders, chains, and any other cargo securing equipment is stowed properly and securely.
- Landing gear—Make sure it is fully raised, isn't damaged, and the handle is secured. Also make sure there isn't any dirt or debris stuck in the pads.
- Lights/reflectors—Check the condition of the reflector tape and light lenses as you walk down the side of the trailer. Clean dirty lenses as you walk around.

- Wheels/tires—Check the overall condition of the tires, rims, and lug nuts to include air pressure and tread wear. Again, check in-between the duals for debris.
- Suspension—Check components for damage, missing parts, and overall condition.
- Brakes—Again, just check the overall condition of the brake components, such as the air canister and the corresponding hardware.
- Mud flaps—Just as with the truck, the trailer needs to have mud flaps and they need to do their job. Replace them as necessary.
- Continue the inspection up the other side of the trailer checking the same components as before.

Start the vehicle

Before starting the vehicle ensure the transmission is placed in the NEUTRAL position and the parking brake is applied. Once the engine is running, stay in the cab and check interior items.

After starting the vehicle, inspect the following interior items:

- Gauges—Make sure as the engine warms, all the gauges are in the proper operating ranges.
- Mirrors/windshield—Mirrors should be clean and adjusted properly (adjusted to you, not the last guy who ran it!); the windshield should be clean without obstructions or damage.
- Emergency equipment—Reflective triangles, fire extinguishers (check the charge!), and a cold weather survival kit if you are in a northern tier base where winter weather is extreme (check with your safety office or supervisor).
- Steering—Check the play in the steering wheel (no more than two-inches of play in a 20-inch wheel). Simply turn the wheel back and forth and watch the front left wheel to see when it engages. Turn the vehicle in if the play exceeds two inches as this could be a potentially dangerous situation.
- Wipers/washers—Check the wiper blades and arms to ensure proper operation. Also, spray the windshield washer to ensure proper operation.
- Lights—Test that dash indicator lights work when corresponding lights are turned on: blinkers, flashers, and high-beam indicator (you will check light function after leaving the cab).
- Horn—Check both the horn in the steering wheel and the air horn (if equipped).
- Heater/defroster—Make sure they work.
- Seatbelts—Check to make sure they are securely mounted, adjust properly, and are not ripped or frayed.
- Parking brake—Make sure the parking brake will hold by putting the vehicle in gear and try to pull forward (gently). If you have a trailer attached, check those brakes too (by disengaging the tractor brakes and engaging the trailer brakes).

Air system check

The purpose of this check is to inform the operator that all brake related safety systems are operating effectively as air pressures drop from a normal to a low pressure condition. First, you will need to shut off the engine and chock the wheels of the vehicle, now inspect the following:

- Leak down—Release the brakes (push in the valve), then push on the brake pedal firmly and hold for one minute. Watch the air pressure gauge for a drop in pressure. A drop of two psi for the tractor alone or a drop of three psi for a tractor-trailer combination could mean a leak in the system and should be checked immediately.

- Warning signal—Turn the ignition key to the on position (to enable electrical power) and begin pumping the brakes continually until the low air buzzer sounds. If the buzzer does not sound (at approximately 60 psi), have it checked by maintenance.
- Failsafe—Continue pumping the brakes until the parking brake valves pop out at approximately 40 psi.

NOTE: These air system checks should be part of a continual maintenance program and as such, don't need to be conducted every day; however, for vehicles that don't get operated every day, it is essential to check to make sure the air system is working properly. For vehicles that sit for long periods of time or are operated in harsh conditions, these checks could save your life.

Service brake check

The final check involves starting the vehicle and pulling forward to check the service brakes. Simply accelerate to about five miles per hour (mph), and then apply the service brakes to make sure they will stop the vehicle. Also, check the tracking of the truck (if it pulls to one side or the other).

Light check

Grab a coworker and conduct a thorough light check to include: clearance lights, headlights (both high and low beam), taillights, backing (or work) lights, turn signals, four-way flashers, and brake lights.

Once completed with this pretrip inspection, sign the AF Form 1800 and you are ready to go. Let's now take a look at the tractor-trailer combination in more detail.

208. Coupling and uncoupling a semitrailer

Before you begin the actual operation of a tractor-trailer, you first need a working knowledge of the procedure for coupling and uncoupling a tractor semitrailer combination. To show you how this is done, we'll present the following subject areas:

- Fifth wheel assembly.
- Procedure for coupling a tractor and semitrailer together.
- Procedure for uncoupling the trailer.
- Landing gear.

Fifth wheel assembly

The tractor and semitrailer are separate units that are joined together by a fifth wheel. The fifth wheel consists of two metal plates (fig. 2–1). One plate, called the lower fifth wheel, is mounted on the tractor. It is illustrated by view A in figure 2–1. The other plate, called the upper fifth wheel, is mounted on the semitrailer (fig. 2–1, view B). When connected, the upper fifth wheel and the lower fifth wheel form a flexible coupling, which permits both rotational and vertical movement between the tractor and semitrailer. As figure 2–1 illustrates, the upper fifth wheel has a kingpin while the lower fifth wheel has locking jaws that lock around the kingpin to couple the tractor and semitrailer together. When not attached to the tractor, the front end of the semitrailer is supported by a retractable two-legged landing gear. The landing gear may be equipped with either wheels or pads.

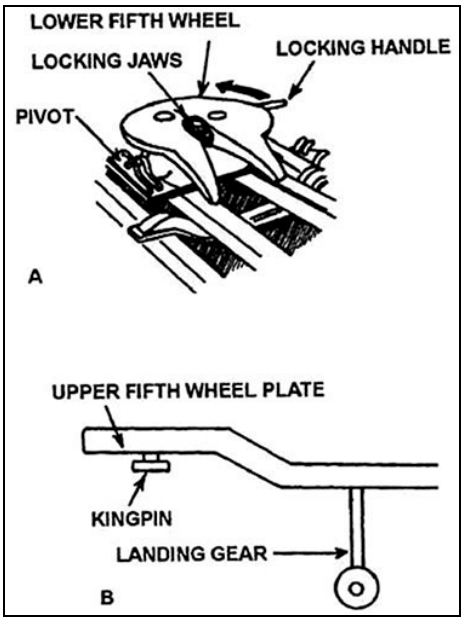


Figure 2–1. Fifth wheel (upper and lower).

Procedure for coupling a tractor and semitrailer together

We will now go through the procedure for coupling a tractor and semitrailer together. The procedures are the same for cargo and lowboy trailers, regardless of their length. Usually, the brakes on a trailer automatically lock when the airlines have been disconnected from the tractor. But for added safety, make sure you block the trailer wheels with wooden blocks (chocks). Also, visually check the back of the tractor to make sure the airlines and electric line are away from the fifth wheel. Now you're ready to hook the tractor and semitrailer together. To do this, follow these eight steps:

1. Position the tractor ahead of and in line with the trailer and back the tractor slowly to the nose of the trailer. Make sure the kingpin on the trailer is in line with the fifth wheel jaws on the tractor.
2. Check the height of the trailer fifth wheel plate to assure it's the proper height to align with the tractor fifth wheel coupler. If not, raise or lower the front end of the trailer as needed.
3. Your next step is to be sure the fifth wheel locking handle is in the OPEN position. Normally, you assure this is done by pulling on the handle until it locks in the OPEN position. There is usually a detent the handle rests in so it doesn't inadvertently close.
4. Connect the airbrake lines from the tractor to the trailer. There are two airbrake lines– SERVICE and EMERGENCY. The SERVICE line carries air that is controlled by the foot brake or the trailer hand brake and is colored blue. The EMERGENCY line supplies air to the trailer's air tanks. The emergency line controls the emergency brakes (the trailer air tanks supply enough air to stop the vehicle in an emergency) and is normally colored red. On newer commercial type tractor-trailers if you cross the airlines, emergency air will be sent to the service line instead of going to charge the trailer air tanks. You can still drive the vehicle, but not for long. It is very important not to cross the lines.
5. Apply trailer brakes by pulling down on the steering column brake lever in the tractor's cab. Release the tractor brake. This will help to prevent the trailer from moving when backing the tractor under the trailer.
6. Back the tractor squarely under the trailer until the fifth wheel has picked up the front of the trailer and the landing gear are off the ground. The tractor should now be backed underneath the trailer with a more forceful motion until the jaws of the lower fifth wheel automatically lock around the kingpin on the trailer. This will throw the lower fifth wheel locking handle into the CLOSED position. Make sure the coupling is secure by trying to pull the tractor forward and away from the trailer.
7. Insert the electric cable into the receptacle on the trailer and secure it into position. Operate the lights from the tractor to make certain all are in working order (grab a coworker and do a light check).
8. Release the landing gear crank from its clip. This crank is usually located underneath the edge of the trailer near the landing gear. Raise the landing gear as high as possible to afford maximum clearance. Place the crank back into its clip. Remove the chock blocks and you are ready to go.

WARNING: Use extreme caution when you connect the air lines and electric cable to the trailer. Wet or icy weather along with accumulated road debris on handholds and steps may easily become slippery. Take extra care to avoid a fall that can cause a serious injury.

Procedure for uncoupling the trailer

Before moving on to operating the tractor-trailer, let's pick up the job knowledge you need for uncoupling a trailer from the tractor. To do this safely, follow these five steps:

1. Set the tractor-trailer parking brakes and place chock blocks on both sides of the trailer, both in front and behind the wheels.
2. Uncouple the two airbrake lines from the couplings on the nose of the trailer.

3. Disconnect the electric cable from the receptacle on the nose of the trailer. Make sure the airline hoses and the electric cable are clear of the fifth wheel area.
4. Remove the landing gear crank from its clip and lower the landing gear until they just start to take the weight off the rear of the tractor. Replace the crank into the clip.
5. Place the lower fifth wheel handle in the OPEN position. Drive the tractor forward until the trailer is free and rests on the landing gear. Pull the tractor out slowly to prevent dropping the weight of the trailer suddenly on the landing gear if the gear isn't in full contact with the ground.

Two other trailers in the AF inventory are the 35-ton and 50-ton breakaway or drop-neck lowboy. We will discuss the breakaway version. These trailers are designed to haul various types of heavy wheeled or tracked equipment. They are built lower to the ground and are stronger than flatbed cargo trailers. A four-cycle, single cylinder gas engine raises and lowers the hydraulic ram located within the trailer gooseneck. The gooseneck is the part of the trailer where the upper fifth wheel is attached, and it actually separates from the trailer's framework. This design does away with the need for loading ramps and allows for easy loading.

The gooseneck and frame (fig. 2–2) are held together in alignment by removable pins or safety locks. After removing or releasing the pins or safety locks and disconnecting the brake and electrical lines, the two units are lowered to the ground by a hydraulic jack in the gooseneck. The gooseneck is then detached from the frame and carried or dragged a short distance by the tractor.

After the tractor is pulled ahead, the equipment can be driven onto the trailer. The gooseneck is then backed back into place, attached, lifted, and locked. In addition to what we've described, you can also load from the rear by backing the trailer up to a loading dock or improvised ramp. Be careful not to damage the trailer's tires as they are exposed though the deck.

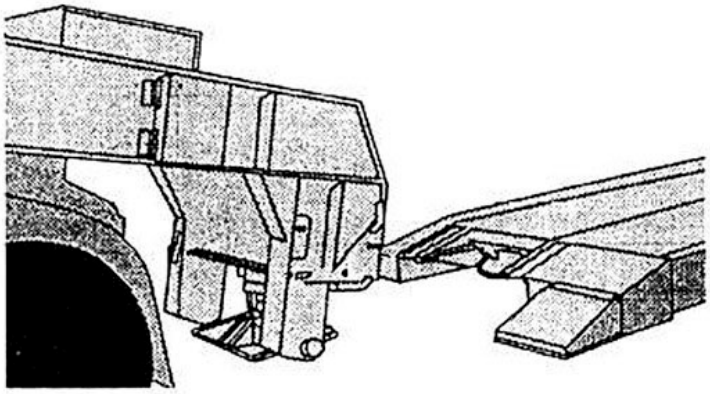


Figure 2–2. Detached gooseneck from trailer.

NOTE: Before you try to connect the gooseneck back to the trailer, make sure the airlines and the electrical cables are out of the way and not in the area where the trailer joins up with the gooseneck. After the gooseneck has been joined with the trailer, you can then reconnect the airlines and the electric cable.

To disconnect the breakaway completely from the trailer follow these steps:

1. Lower the hydraulic ram and raise the gooseneck.
2. Disconnect the two airbrake lines and the electric cable on the front of the gooseneck.
3. Place the lower fifth wheel handle in the OPEN position and drive the tractor forward.
4. Raise the hydraulic ram all the way up and let the trailer rest on the ground.

To connect the tractor to the trailer, reverse these procedures.

CAUTION: Breakaway trailers have low ground clearance; be sure to use extreme care when crossing any high point in the roadway such as railroad tracks, speed bumps, and dips.

Landing gear

Although all landing gear on trailers serves the same purpose, not all are of the same style. Most trailers use a pad style landing gear to make contact with the ground; however, some may incorporate wheels. Another difference is in lowering or raising the landing gear. Some are lowered or raised using just one hand crank, while other styles use two. Regardless of the style of landing gear equipped with the trailer, when you park on soft ground or asphalt, always use a board or some other type of material under the landing gear to prevent sinking.

209. Operating a tractor-trailer on the road

Operating the tractor-trailer is much more difficult than operating most other vehicles. You must allow for the added length when turning or backing, and when passing other vehicles. You must also consider space for maneuvering this larger unit into position for loading and unloading. In this lesson, you'll cover the following special techniques needed for these tractor-trailer procedures:

- Turning.
- Backing.
- Accelerating.
- Slowing and stopping.

Turning

When making a turn with the tractor-trailer, you must allow for the overall length of the unit. Keep in mind the trailer has a tendency to cut corners rather than follow the tractor. When performing a right-hand turn, turn slowly to give yourself and others time to avoid problems. Put your turn signal on well in advance to warn other drivers of your right turn. If you can't make the right turn without swinging into another lane, turn wide as you complete the turn, this is called a button hook (fig. 2–3, view A). Keep the rear of the tractor-trailer close to the curb to stop any drivers from passing on the right. If you must cross into the oncoming traffic lane when making your turn, watch for vehicles coming toward you. Give them room to go by or stop; however, DO NOT BACK-UP for them because you may have a vehicle directly behind you.

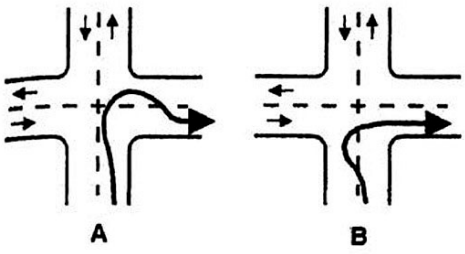


Figure 2–3. Right turn.

When making your right turn, avoid turning wide to the left, often called a jug handle (fig. 2–3, view B). If you do, a following driver may think you're turning left and try to pass you on the right. Remember turning too sharply while making a right turn will cause the trailer to ride up on the curb and possibly run over obstructions (fig. 2–4).

When making a left turn, make sure you have reached the center of the intersection before you start your turn. If you turn too soon, the left side of your vehicle may hit another vehicle because of off tracking (fig. 2–5).

If there are two turning lanes, always take the right-hand turn lane (fig. 2–6). If you start your left turn in the inside lane, you may have to swing to the right to make the turn. In doing this, you may not be able to see vehicles on your right and possibly cause a collision. Also, your trailer may clip the front of the car waiting at the light. Always stay to the right when making a left-hand turn.

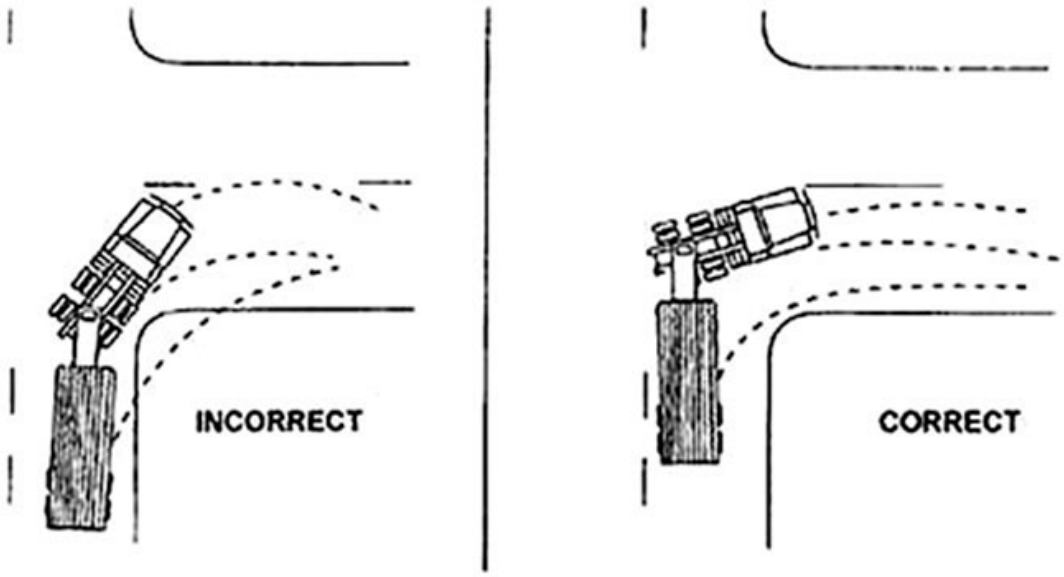


Figure 2–4. Correct and incorrect right turn.

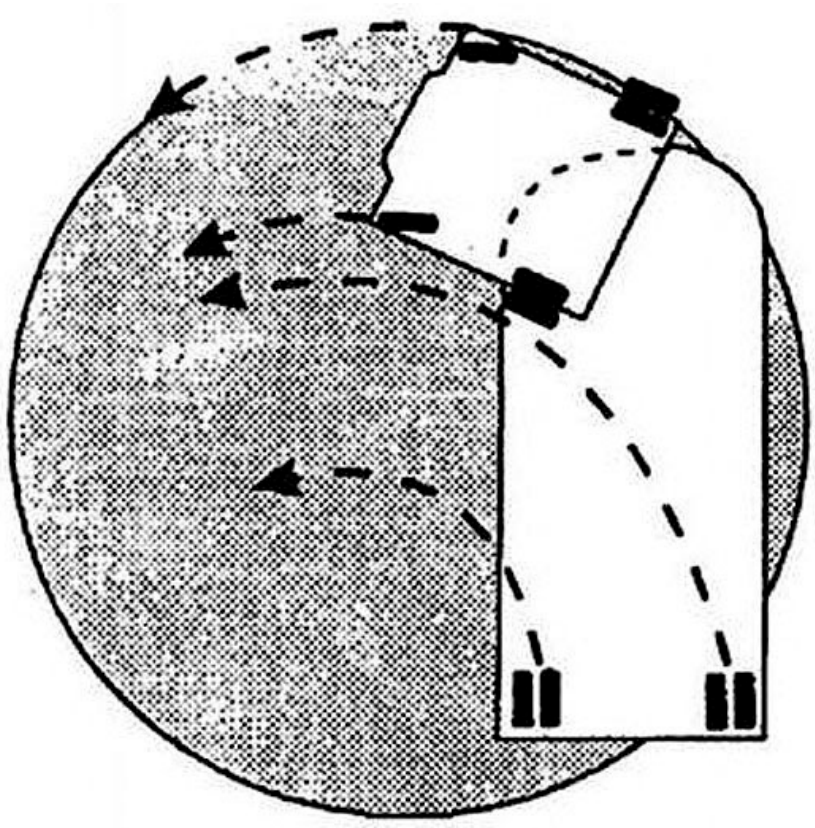


Figure 2–5. Tractor trailer left turn off tracking.

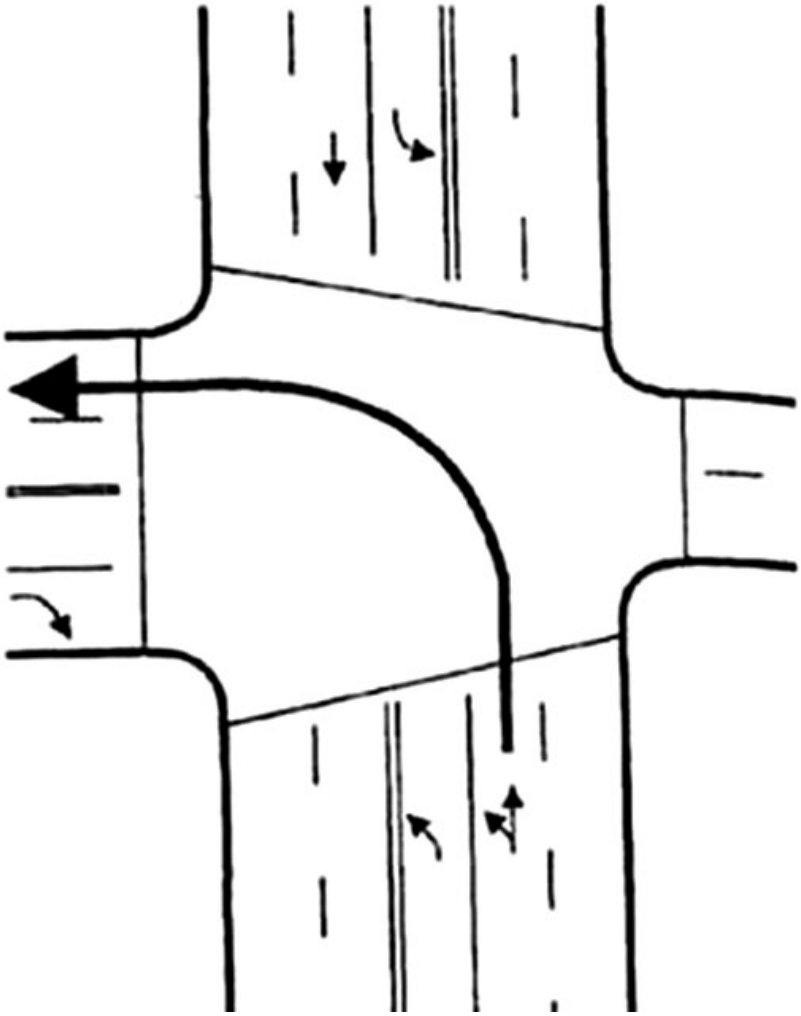


Figure 2–6. Left turn from right-hand lane.

Backing

When backing a tractor-trailer, reverse the procedures you use to back a straight truck. For example, if you want the trailer to go to the left, turn the steering wheel to the right. After the trailer is headed in the desired direction, turn the steering wheel slowly to the left. This puts the tractor in the same line of travel as the trailer and prevents the tractor-trailer from jackknifing. The term “jackknife” denotes a condition where the tractor-trailer becomes jammed together at an acute angle.

Backing the tractor to the left is known as sight side backing and is the preferred method. When backing to the left, you have a better view of the area into which you’re backing (fig. 2–7). Even though the view of the area is better from the left, a spotter is required.

Reverse the procedures to back the trailer to the right. This is called blind side backing and should be done only when it’s necessary. As you can see from figure 2–8, you can’t see the rear of your trailer or the area into which you’re backing. For this reason, as with backing any vehicle or piece of equipment, a spotter is mandatory. Always try and know the area you will be backing into prior to committing to it. If possible, park somewhere near the area and get out to take a look. Make a visual inspection of the area to know the best way to get in and the best way to get out.

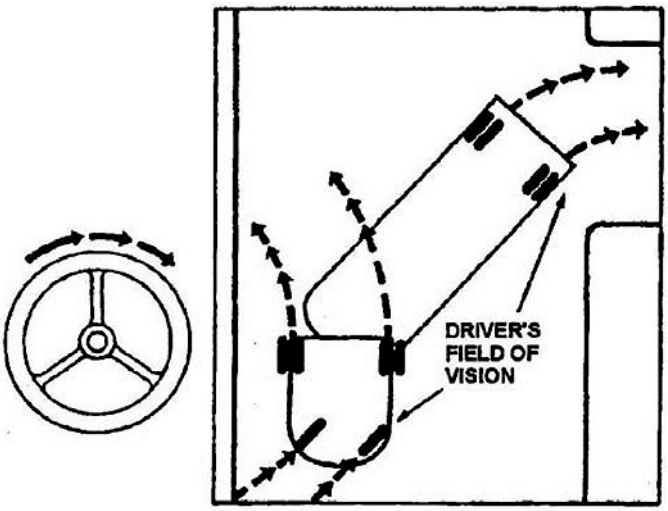


Figure 2–7. Backing semitrailer (sight side).

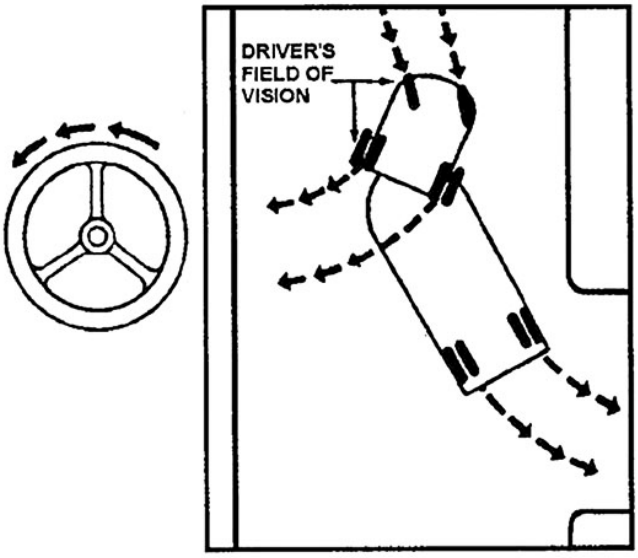


Figure 2–8. Backing semitrailer (blind side).

Accelerating

When you drive a tractor-trailer, avoid rolling backward when you start because you may hit a vehicle behind you. To avoid rolling back, partly engage the clutch before taking your right foot off the brake (manual transmission). Even with an automatic transmission, there is a chance of rolling back. Simply hold the brake with one foot and apply some throttle to make sure you don't roll back when starting out. If on an incline, engage the trailer handbrake to hold the tractor, and then release the brake only when you have applied enough engine revolutions per minute (RPM) to keep from rolling backward.

Accelerate smoothly and gradually so the tractor doesn't jerk. Rough acceleration causes unnecessary premature mechanical damage to the drive train and to the coupling. You will need to speed up gradually when traction is poor like on wet or snowy roads. Because using too much power may cause the drive wheels to spin. If the drive wheels lose traction, don't apply the brakes; just take your foot off the accelerator pedal.

Slowing and stopping

In normal operations, use the foot (service) brakes alone since they control both the tractor-trailer simultaneously. The most efficient braking power is at the point before the brakes lock up. A loaded tractor-trailer usually stops quicker than an unloaded combination due to the extra traction. On vehicles with antilock brakes, the system regulates braking pressure in a way that doesn't allow the brakes to lock up, therefore, aiding in stopping the vehicle safely during emergency braking situations. Antilock brakes will not replace sound judgment and skill.

The trailer brakes can be controlled independently of the tractor brakes. This is done with a lever usually mounted on the steering column. The trailer handbrake should never be used alone to stop the tractor-trailer. The best use of the trailer handbrake is for preventing rollback when stopped on an incline.

Braking in an emergency or under hazardous road conditions, such as steep grades or slippery surfaces, creates the most difficult situation to maintain control and stopping of your tractor-trailer. Jackknifing is also caused by skidding or locking the wheels, normally due to hard braking in emergency or hazardous conditions. Locked or skidding wheels will tend to take the lead or come around to one side. Control must be regained immediately if it is to be regained at all. To regain control, quickly release the brakes to get the wheels turning and **DO NOT** use the trailer handbrake, which can exacerbate the situation.

Brake fade and brake failure occur when the service brakes are overused or out of adjustment. If you continually use the brakes while descending a steep grade, expect break fade. The way to combat this situation is to employ proper braking techniques. Downshift into a gear suitable for descending the hill before you crest the top. In this way, you use the braking power of the engine (compression resistance) to slow the vehicle. Then, choose a safe speed as a guideline (usually the posted speed for trucks), and don't let the vehicle get above that speed. For instance, if the posted truck speed is 40 mph, enter the hill at approximately 35 mph. When your vehicle reaches 40 mph, apply firm steady breaking pressure until your speed drops to 35 mph again, then release the brakes. Repeat this technique until you reach the bottom. Don't "ride" the brakes downhill. This creates excessive heat, which aids brake fade and eventually failure.

If you find your vehicle's speed is increasing too quickly, you are probably in the wrong gear and will have to take the necessary steps to slow your vehicle down. This could mean an emergency stop along the shoulder, a pull-off, or an emergency truck ramp. It's better to err on the side of caution when your brakes are concerned.

Following distance

As a general rule-of-thumb, when figuring out how much distance you need in between you and the vehicle in front of you, add one second for each foot of your vehicle's length for speeds 40 mph and under. For speeds above 40 mph, add an additional one second to the total. Simply pick a spot in the road and wait for the vehicle to pass it before counting.

For example: If your vehicle is 50 feet long (a tri-axle 50-ton lowboy with a 20-ton tractor with a drop axle is extremely long!), and you will be traveling primarily below 40 mph, your total stopping distance would be five seconds. If you decide to take the interstate, and will be traveling above 40 mph, add another second for a total of six.

This may seem like a long distance, but think about how long it takes to stop a fully loaded tractor-trailer combination. Even under ideal road conditions, it could take upwards of 450 feet to stop at speeds of 55 mph (longer at higher speeds). Compare that to a small car which can stop in 120 feet. The math is fairly easy; if you are tailgating that small car (one second following distance), you will have run it over and the two cars ahead of it in the time it takes for you to stop!

Remember that road conditions will also dictate following distances. If there is fog, rain, icy conditions or even lots of traffic, slow down. Try to maintain those following distances.

Other operations

Now that we've discussed the basics for tractor-trailer operations, we'll turn our attention to five other important subjects you need to know. They are as follows:

- Multispeed rear axles and auxiliary transmissions.
- Automatic transmissions.
- Retarders.
- Parking.
- Draining air tanks.

Multispeed rear axles and auxiliary transmissions

These two systems are used on many tractors to provide extra gears. These gears are shifted by a selector knob or switch on the gearshift lever to the main transmission. Many different transmission shifting patterns are used; therefore, it's important you study the operator's manual before operating a tractor with an unfamiliar transmission pattern.

Automatic transmissions

Many tractors in the AF inventory are equipped with automatic transmissions. A low range can be selected to have greater engine braking power when going down grades. The lower ranges prevent the transmission from shifting up beyond the selected gears; however, shifting an automatic transmission incorrectly can cause serious damage to the transmission. Before operation, you must study the operator's manual for techniques of shifting the automatic transmission.

Retarders

Some tractors are equipped with a retarder that helps to slow a vehicle, thus reducing the need for using the brakes. Retarders reduce brake wear and provide another means to slow down. The retarders are controlled by the operator and are either exhaust, engine, hydraulic, or electric.

Parking

When you park a tractor-trailer, don't set the airbrakes and depend on them to hold the vehicle. Instead, place chock blocks before or behind the wheels as required to keep the wheels from rolling if the unit is to be left unattended.

Draining air tanks

The brakes on tractor-trailer systems are air operated. To keep them operating efficiently, frequently open the petcocks on the air tanks to drain any condensation. If this water isn't drained, it could cause corrosion or rust inside the brake system. If the corrosion or rust flakes off, particles forced through the lines could cause failure or poor operation of parts of the brake system. Also, this water could freeze inside the tank or lines. After draining the water from the tank, be sure you close the petcock immediately; don't wait until the next time you operate the vehicle. It's the condensation you want to remove from the tank, not all the air.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

207. Inspection

1. What is the purpose of the pretrip inspection?

2. Why should your unit establish checklists or procedures to follow in the case of tractor-trailer combination pretrip inspections?

3. Where do you begin the pretrip inspection?

4. What are unacceptable pressure drops during the leak down test?

5. At what pressure will the parking brake valves automatically pop out?

208. Coupling and uncoupling a semitrailer

1. What is the purpose of the fifth wheel?

2. What is the purpose of the landing gear?

3. How can you be sure the locking handle is in the OPEN position?

4. Why should you pull out from under the trailer slowly when uncoupling?

5. What precaution should you take when parking a trailer on soft ground or asphalt?

209. Operating a tractor-trailer on the road

1. What should you do to prevent a car from trying to pass on your right when you are preparing to make a right turn with a tractor-trailer?

2. If you turn the steering wheel to the right when backing a tractor-trailer, what direction will the rear of the trailer go?

3. If you must back a trailer, in which direction (right or left) is the preferred method? Why?

4. What damage can occur through rough acceleration?

5. If you are driving over dry and level pavement, how do you brake for a normal stop with a tractor-trailer?

6. If you are driving a tractor-trailer and have to stop on an incline, what brake system would you use to prevent a rollback?

7. What can cause jackknifing?

8. What is the appropriate following distance for a 40-foot combination traveling at 55 mph in ideal weather conditions?

9. How can you prevent condensation in an airbrake system from freezing or rusting the system?

10. What function does the retarder serve on the tractor?

2–2. Hauling Cargo

The material and equipment you haul, whether it's with a one-ton pickup or a tractor-trailer, are your responsibility. To protect yourself from being held liable for the loss or damage of material and equipment, or damage to your or someone else's vehicle, you must have the knowledge of the proper handling and loading procedures.

210. Cargo distribution and loading procedures

Many truck accidents are the result of improper load distribution and procedures. Often the trucker states, "My load shifted and I couldn't control my truck." In other cases, entire loads are scattered about because the load wasn't properly secured. The discussions and examples we'll present in this lesson are designed to help you avoid the situations we've described.

This lesson will cover the following subjects:

- Proper load distribution.
- Loading rules.
- Load security.

Proper load distribution

Before you even think about loading a vehicle, you need to know its weight capacity. You can get this information from the manufacturer's specification plate or from the operator's manual. At times other people will load your vehicle. Since you'll be held accountable for the materials and equipment you haul, you should stay with your vehicle to make sure it's loaded properly. Proper loading includes proper weight distribution. Keep in mind, the vehicle's capacity doesn't have to be reached to overload it. Figure 2–9 illustrates many examples where the placements of a concentrated load in one certain area can cause a vehicle to be overloaded. If the load is unbalanced, it could damage the vehicle or in some cases cause the vehicle to overturn. In addition to the examples in figure 2–9, one loose or improperly loaded piece of equipment may release an entire load or damage the cargo.

Loading rules

By following these rules, you will ensure your cargo is loaded properly:

- When loading heavy and light cargo together, place the heavier cargo on the bottom. This prevents you from having a top-heavy load. It may also prevent damage to the lighter cargo, which could result from its having to support the heavier cargo.
- Distribute the load evenly over the bed of the vehicle or on the trailer. Most loads are heavy enough to damage the vehicle or cause difficult handling if not properly distributed. Look again at figure 2–9 for the right and wrong ways of distributing loads.
- In building up the load, place the cargo carefully to avoid its shifting. Loosely stacked loads shouldn't be built up too high. High, loose loads cause swaying and increase the danger of cargo loss.
- Load barrels and drums on their sides parallel to the length of the truck or stand them upright (fig. 2–10). If you load them on their sides, block and build a pyramid to secure them. Block or tie upright barrels to prevent their shifting or overturning.
- Stack items in overlapping layers to prevent their shifting.
- Never load acetylene cylinders in any position other than vertical. Be sure they're securely anchored to prevent their overturning.
- Mark the extreme end of any long article projecting four feet or more beyond the rear of the vehicle or trailer with a red flag during daylight or a red light at night. Check with your state DOT for rules regarding "oversize" loads if you will be traveling down interstate roadways.
- If you have any questions or doubts about being overloaded, overextended, or improperly loaded, check with your supervisor or state DOT. It's better to be safe now than to be sorry later.

Load security

After you make sure the load is loaded properly on the vehicle or trailer, you must also ensure it is secured enough to prevent any shifting or falling that could cause damage to the load, your vehicle, other vehicles, or personal injury to yourself or someone else. The method and securing devices (chains, binders, and tie-down straps) you use to secure the load depends on the type of material or equipment, the speed, and the distance of travel. Even if a very short distance is to be traveled at a slow rate of speed, a load that isn't secured is subject to shifting or falling off, especially on turns. The main thing to remember is if you're going to transport it, **SECURE IT**.

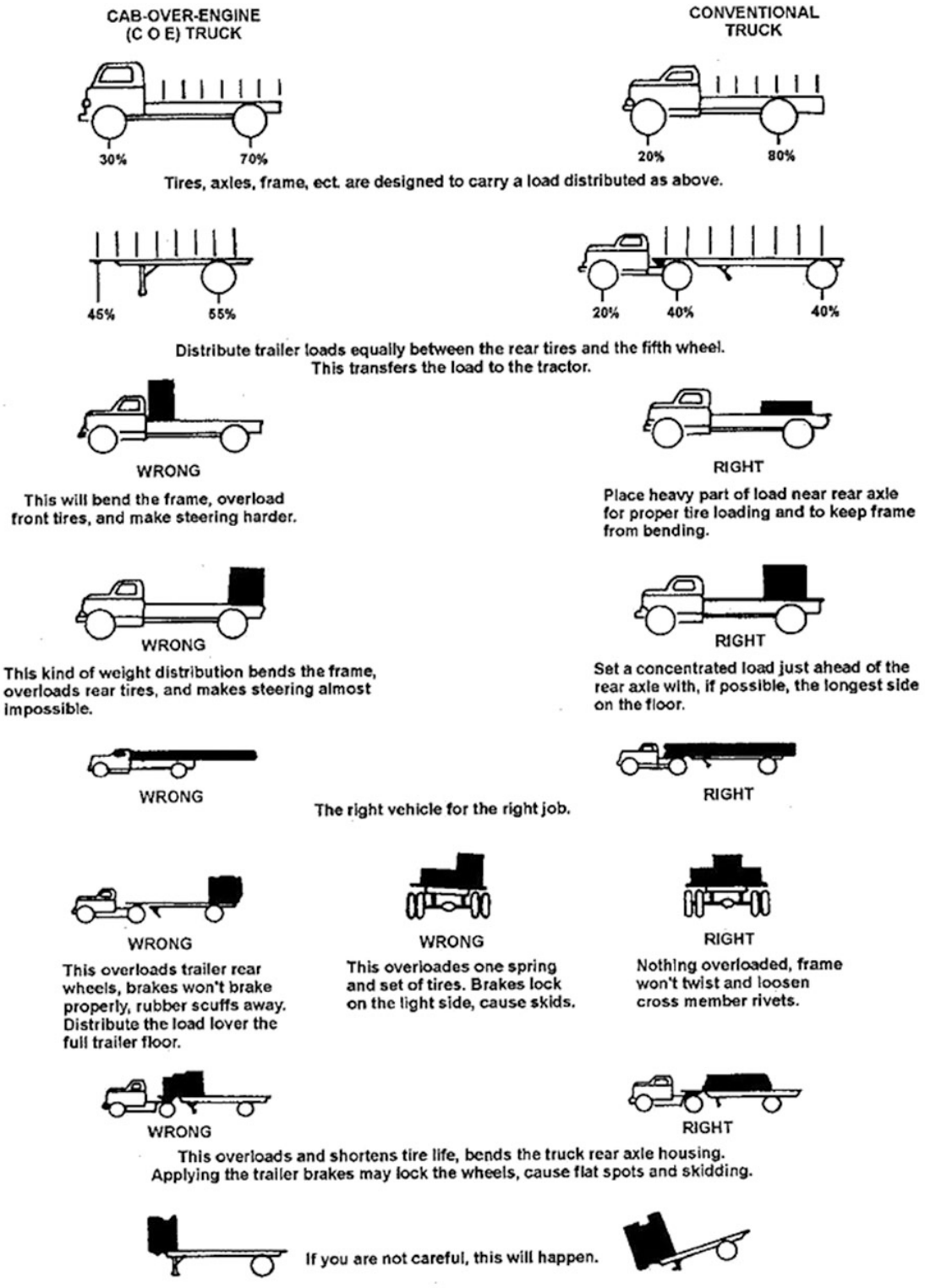


Figure 2–9. Distribution of loads over vehicle bed.

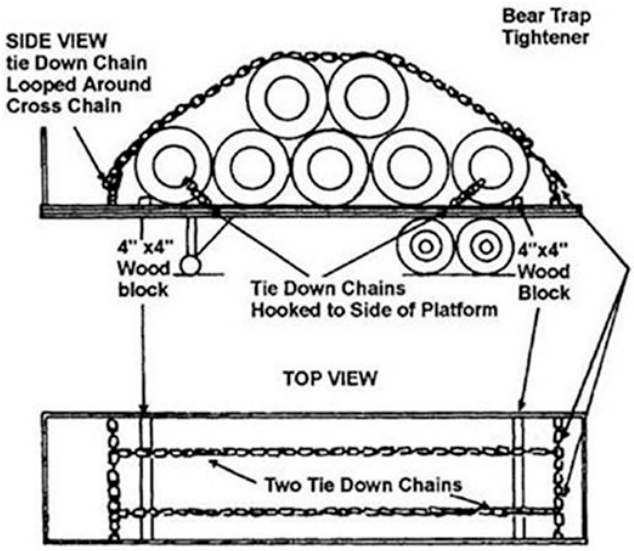


Figure 2–10. Loading barrels and drums on vehicle bed.

211. Hauling construction materials and equipment

In our last lesson, we discussed the important distribution and loading procedures that are involved in tractor-trailer operations. Now that you are well-versed in these subjects, we'll turn our attention to where the "rubber meets the road"—hauling construction materials and equipment.

Construction materials

For our lesson, we'll use a practical example. Let's say you're tasked to haul a large quantity of prefabricated airfield landing mats. The mats are 12 feet long and two feet wide. There are 12 mats per bundle. Since it's the most likely piece of equipment to use, let's also say you're going to use a forklift to load and unload the mats.

Begin the job by placing the trailer beside the mats. Leave enough room between the trailer and the stack of mats to allow the forklift working space. Place four-by-fours or other suitable blocking material (dunnage) across the trailer floor. Set the mats on the four by fours. If the forklift will reach far enough, you can load from one side. After you get the first tier loaded, place four-by-fours on top and load another tier. Make certain you pay close attention to the height restrictions when loading the mats on the trailer.

NOTE: Most times, you will exceed the height restrictions before you meet the weight restrictions.

When you have the vehicle loaded, secure the mats with two chains across each row. Place wooden dunnage on the mats where the chains cross over to prevent damage to the aluminum matting. Hook the chains securely and tighten them with load binders. Load binders are chain-tightening devices used to help secure loads and are usually made of iron with swivels, two chain hooks, and a lever (fig. 2–11).

Figure 2–12 illustrates the right and wrong ways to use a lever load binder. The top binder is a ratchet binder and is preferred due to its ease of operation (simply ratchet it until it's tight) and safety. As you can see by the lower illustration of the lever load binder, you hook one binder hook on the chain near the trailer and the other higher up, and then tighten the chain by pulling the lever down. The lever will stay in place as long as the chain is tight and the lever is secure. To secure the lever of the binder, fasten the binder safety hooks or use safety wire to keep the binder closed. To release the binder, undo the safety hooks and/or safety wire, and push the lever up and away from the chain. This is when the lever load binder is most dangerous, so take extreme care when releasing the lever. There is a huge amount of stored energy when they are tight. The lever can release with great force and cause you harm if you don't do it properly.

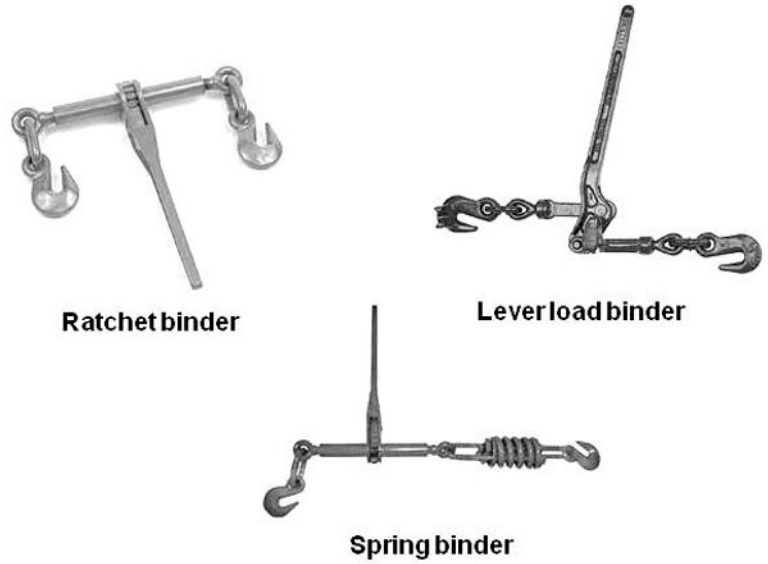


Figure 2–11. Assorted load binders.

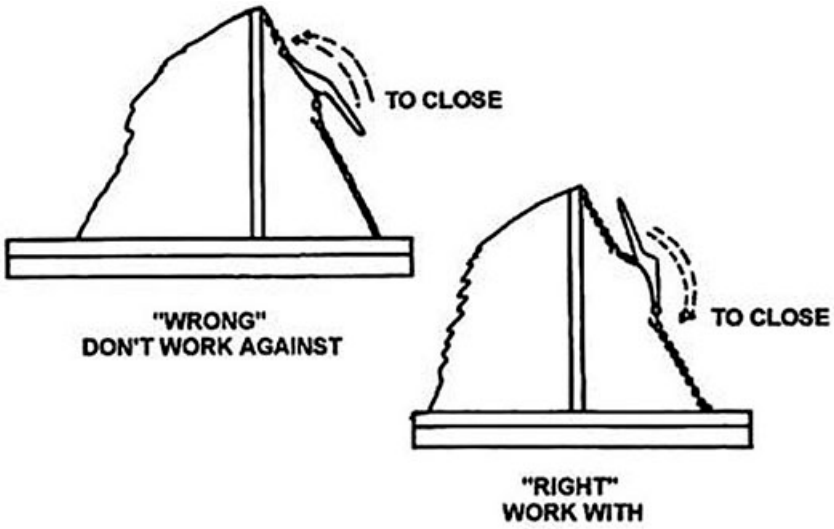


Figure 2–12. Using lever load binders.

CAUTION: Before you release the binders or straps, check to see if the load has shifted while in transit. If it has, the load could fall when the security chains or straps are removed. Don't stand directly in front of the binders when you release them; instead, stand off to the side. A serious injury can result from being hit with a lever load binder.

After you drive from the loading point to the unloading point, park the tractor-trailer so there's sufficient forklift working room. Release the load binders and remove the chains. Place four-by-fours on the ground at the point where you want to stack the mats. The four-by-fours will serve the following three purposes:

- Allow the forklift forks to slip out easily.
- Keep the mats out of mud and water in wet weather.
- Allow the forklift forks to be easily slipped under the mats in the future.

Our mat example is only one type of construction material that you may haul. With minor variations in the procedure, you haul all construction materials in the same manner.

Construction equipment

Tracked equipment, such as dozers and asphalt pavers, and slow moving equipment such as steel wheel rollers must be hauled from one job site to another. For our discussion on hauling construction equipment, we'll use the example of hauling a dozer. We'll also take a brief look at how you haul rubber-tired equipment. We'll conclude the lesson with a short discussion on the loading characteristics of breakaway trailers.

Hauling a dozer

There are several reasons for hauling a dozer. Speed, wear on equipment, and protection of roads and improved areas (grass, landscaped) are only some of them. This doesn't mean you must always haul dozers. Let's say for example, you must move a dozer about one-half mile from a completed job to a new one on the airfield. To do this, you must cross a taxiway to get to the new job site. You would probably save time by walking (driving) the dozer to the taxiway, laying down old tires or thick wide board, and crossing the taxiway on them. If you don't have enough tires or boards to go completely cross the taxiway, move the tires or boards ahead of the dozer as soon as the dozer moves off of them. You don't have to worry too much about tearing up the airfield sod as airfield grounds are semi-improved grounds. On the other hand, if you were to move a dozer as little as a block on the main part of the base, you'd have to haul it to keep from tearing up the improved grounds.

The first job of hauling a dozer is to load it on the lowboy trailer. Most equipment parking areas have a loading ramp. Some are earth or gravel confined by wooden walls. In construction areas, there's usually a pile of dirt pushed up for use as a loading ramp. If none of these are available, you can back the trailer into a shallow dry ditch against a low bank, or push a pile of dirt up behind the trailer and use it as a loading ramp. When pushing material up against the back of the trailer, be careful so you don't break the trailer lights. If you're in an area where a ramp is unavailable and you can't push up a pile of dirt, use portable loading ramps if available. You use these ramps by hooking them on the back of the trailer in the slots provided. If the ramps are kept in the equipment yard, use an available forklift to bring them out to the site. If not, these ramps will have to be handled by hand.

Follow these ten basic steps when you load a dozer on the trailer:

1. Use a spotter and align the dozer tracks with the loading ramp.
2. Raise the blade high enough to clear both the loading ramp and trailer, but not so high as to hinder your view.
3. Put the dozer transmission in forward and slowly move up the ramp.
4. Walk the dozer onto the trailer always making sure the dozer is centered on the trailer.
5. Before the dozer is all the way forward, lower the blade onto the trailer.
6. Push the blade firmly against the trailer and set the blade in the FLOAT position.
7. Put the dozer transmission in neutral.
8. Apply the parking brake.
9. Stop the engine.
10. Secure the dozer to the trailer with chains and binders.

NOTE: To unload the dozer off the trailer, reverse the procedures we just discussed.

Securing equipment

Choose chains and binders that are in good condition, free from stretched or damaged links and bent hooks. Inspect chains and binders prior to using them and look for the tag that states the chain's rated capacity. If you know the vehicles weight, figuring out how many chains to use is simple math. For example: If the dozer weighs 46,000 pounds (lbs) and your chains are rated at 10,000 lbs each, you would need five chains (four chains equals 40,000 and one extra to compensate for the 6,000 lbs. left). Theoretically, when you are done securing your load, you should be able to pick up the trailer

and flip it upside down. The load should stay put without sliding or coming off the trailer. Realistically, in an accident, your load should stay with the trailer.

Choose tie-down points that are easy to reach and easy to see the chains from the cab of the truck. For the dozer example, use two chains on each side from the rear of the machine pulling towards the center of the trailer and from the front of the machine pulling to the center of the trailer. This configuration has the four chains pulling against each other and has a better chance of staying secure throughout the trip. The remaining chain needs to be used to secure the blade.

Once the chains and binders are set, secure the ends of the chains and the levers of the binders. An unsecured ratchet binder's lever could loosen due to vibration and bouncing. Simply lashing everything down will help to alleviate this.

When hauling the dozer, chances are the blade will be wider than the trailer. If it is, and you have to drive through traffic, display a sign on the front of the tractor and the back of the trailer that reads "**DANGER—WIDE LOAD**" or "**OVERSIZE LOAD.**" Also, tie red flags on the outer most part of the blade. Whenever possible, get escort support from the security police during travel. Be careful when passing parked cars and other like objects so you don't catch them with the blade.

Hauling rubber-tired equipment

You may also have to haul rubber-tired equipment, such as a front-end loader, to a job site (fig. 2–13). As with hauling the dozer, it's an absolute must that you tie the equipment down securely to the trailer. Figure 2–14, shows just one example of the placement of tie down chains (assuming the loader is approximately 30,000 lbs).

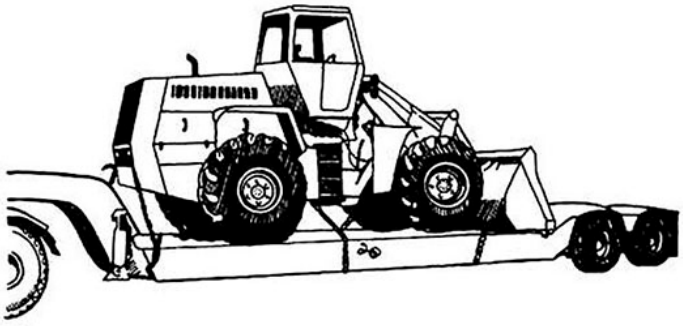


Figure 2–13. Front-end loader ready for hauling.

When tying down rubber-tired equipment, use the spring binders (fig. 2–11). The reason we use them is due to the bounce created by the tires. The spring lets the machine move without damaging the chains or binders. If you tie a rubber-tired vehicle down without spring binders, the chains tend to loosen and then snap tight during a bounce. This creates a shock load on the chains, which could potentially break a chain creating an extreme hazard. Another way to prevent the shock loading is to block the vehicle up. Simply insert blocks under the axles large enough to take the weight off the tires but not so tall as to increase the vehicles center of gravity (CG). Then, tie the vehicle down as you would for a nonrubber-tired vehicle.

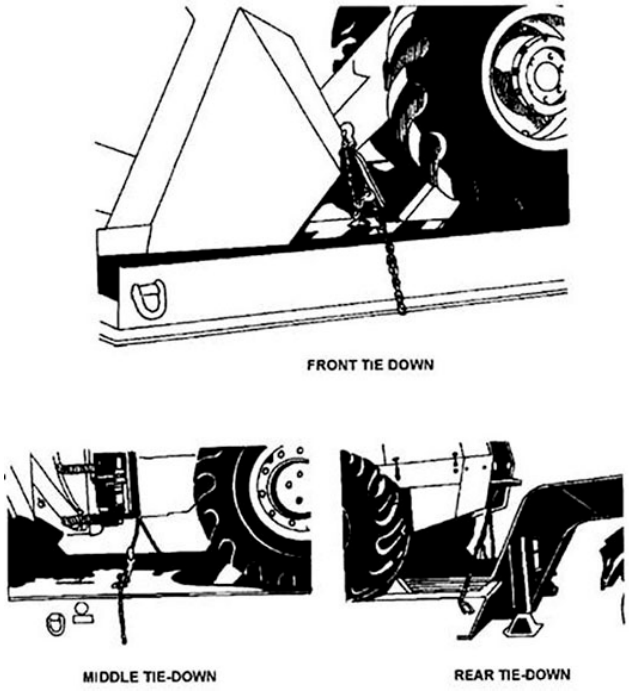


Figure 2–14. Front-end loader tiedowns.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

210. Cargo distribution and loading procedures

1. What could cause a vehicle to be overloaded without the vehicle capacity being reached?

2. When loading heavy and light cargo together, how should you place the cargo on the vehicle?

3. If you are hauling drums or barrels, what is the best way to secure the load if the drums and barrels are placed on their sides?

4. How should long articles projecting four feet or more beyond the rear of the vehicle be marked to warn other motorists?

5. What determines the method you should use to secure cargo on a vehicle?

211. Hauling construction materials and equipment

1. What is the purpose of load binders?

2. How do you secure the lever on a binder?

3. What are three reasons for hauling construction equipment?

4. What materials may be used to walk a dozer across a taxiway?

5. If no loading ramp is available, what method can be used to load a dozer on a lowboy?

6. After a dozer is loaded, where should the blade be positioned?

7. How many chains are needed to secure a 38,000 pound D–5 dozer to a lowboy trailer?

8. When hauling a dozer with a blade wider than the trailer, what should you do?

2–3. Forklifts

Forklifts fall within the general category of MHE as denoted by the OSHA and consequently Air Force Occupational Safety and Health (AFOSH). Because of this, they have specific rules and regulations concerning their operation such as training criteria and licensing procedures. This is to ensure that operators are able to conduct operations safely. A forklift is a valuable piece of machinery to aid us in completing the AF mission around the world. Forklifts are also known as powered industrial trucks or lift trucks. They are designed to lift and transport material typically loaded on either a wooden pallet or 463L aircraft pallet.

212. Forklift overview

The AF owns and operates many different types of forklifts which we will briefly discuss. Four thousand to six thousand (4–6K) capacity warehouse forklifts are perfect for warehouse situations and have specific abilities and some limitations. The warehouse forklift's biggest limitation is that it is inefficient operating in any situation other than on smooth flat surfaces. As pavements and construction equipment operators, we operate in locations where warehouse forklifts cannot perform and therefore, don't come in contact with them very often. Our forklift of choice is the fork attachment for loaders or 10K AT (all terrain). These types of forklifts are considered "AT" or "RT" (rough terrain) and therefore, we will concentrate on those.

Major components

The forklift has several major components which apply to all forklifts (fig. 2–15). We will briefly discuss them.

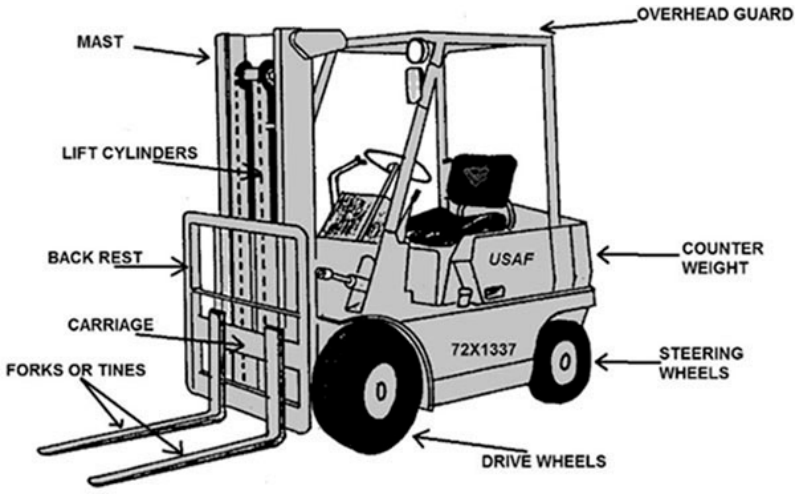


Figure 2–15. Major parts of a forklift.

Mast and lift cylinder

The mast is the vertical assembly that raises, lowers, and tilts the load. The mast supports the carriage, which allows its vertical movement with the hydraulic lift. The lift cylinder supplies the power to raise and lower the load. Mast configurations affect your visibility when operating the forklift. You should always travel with the load trailing, and use a spotter whenever necessary to have proper visibility.

Carriage

The carriage is made of flat metal plates that move along the mast by chains or are directly attached to the hydraulic cylinder.

Forks

The forks (or tines) carry the load. They curve upward and connect to the shank where they are attached to the carriage.

Drive wheels

The drive wheels are actually the front wheels on forklifts. The front wheels serve as the fulcrum point between the weight of the truck and weight of the load being carried. We will talk more about this later.

Steering wheels

The steering wheels are the rear wheels of the forklift. This gives you greater control of the truck when you are using the forks. This also requires you to become familiar with the way the forklift handles compared to a typical automobile with the steering wheels in the front.

Counterweight

The counterweight is a mass attached to the rear of the forklift frame. The purpose is to counterbalance the load being lifted.

Overhead guard

The overhead guard is a metal frame attached to posts designed to protect you from falling objects.

Stability triangle

If you were to raise a forklift up and look at it from the bottom, you would view the support points in views A, B, and C. The triangle formed (fig. 2–16, views A, B, and C) between points A, B, and C is called the stability triangle. The forklift will not tip over as long as the CG remains inside the triangle. If the CG shifts outside the stability triangle, the forklift will tip over. The front wheels of a forklift serve as the fulcrum point between the weight of the forklift counterweight and the weight of the load being carried. If the weight of the load being lifted is equal to or greater than the weight of the counterweight of the forklift, it is possible for the forklift to “seesaw” on its front wheels. The safety of transporting a load increases when you keep a load lower to the ground and closer to the fulcrum point of the forklift.

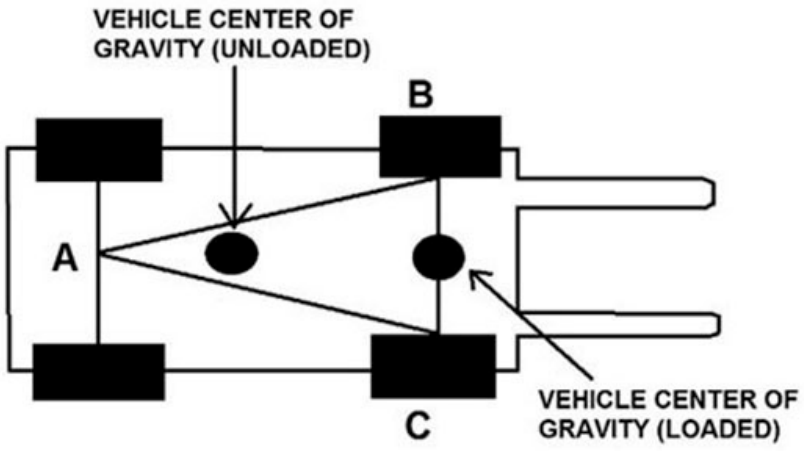


Figure 2–16. Forklift stability triangle.

Center of gravity

This refers to the point on an object at which all of the object’s weight is concentrated. For symmetrical loads, the CG is at the middle of the load.

Counterweight

This is the weight that is built into the forklift's basic structure and is used to offset the load's weight and to maximize the vehicle's resistance to tipping over.

Fulcrum

This is the forklift's axis of rotation if or when it tips over.

Grade

Refers to the slope of a surface, which is usually measured as the number of feet of rise or fall over a hundred-foot horizontal distance (the slope is expressed as a percent).

Load center

This is the horizontal distance from the load's edge (or the fork's or other attachment's vertical face) to the load's CG.

Load capacity

The highest capacity of a forklift applies with the upright or mast in vertical position (fig. 2–17). Load centers are determined for the front face of the fork. Capacities are based on a cube load configuration with the CG at the true center of the cube with standard forks. Tilting the mast forward will reduce the lift capacity. This information is found on the data plate. If the load is not centered at the specified position, the forklift's capacity will be reduced. Loads come in all shapes and sizes. The load size, position, and weight distribution affects the forklifts stability.

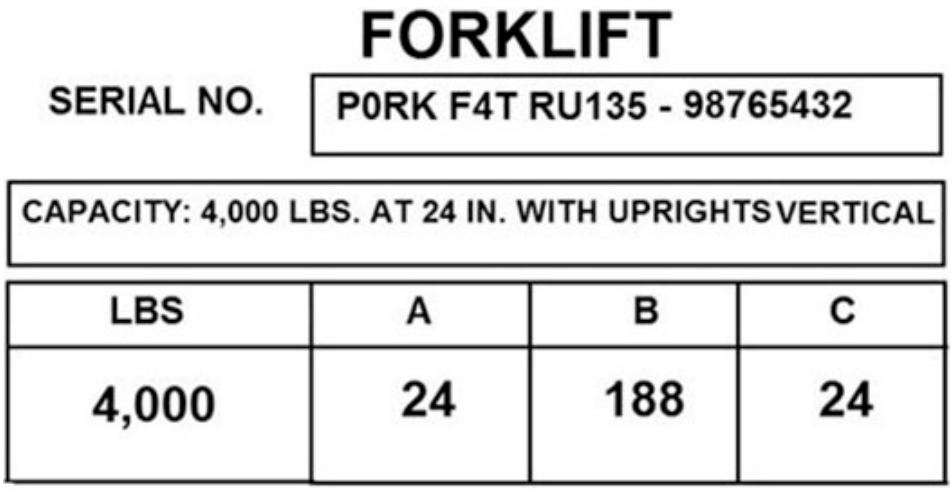


Figure 2–17. Forklift load capacity data plate example.

Forklifts are designed to carry a capacity load at a standard load center, which is typically 24-inches. This means that the forklifts capacity was determined as if the load were a cube whose weight is evenly distributed and is resting on a standard pallet having dimensions of 48 inches by 48 inches. The horizontal distance from the center of the load to the vertical part of the forks would be 24 inches (fig. 2–18).

In figure 2–18, we will assume a load is a 48-inch cube that weighs 4,000 lbs, the CG of the load is identified in the center of the load at 24 inches, these measurements are identified as A and C. Finally, the measurement of B identifies the maximum lift height capability of the forklift. This information is located on the data plate.

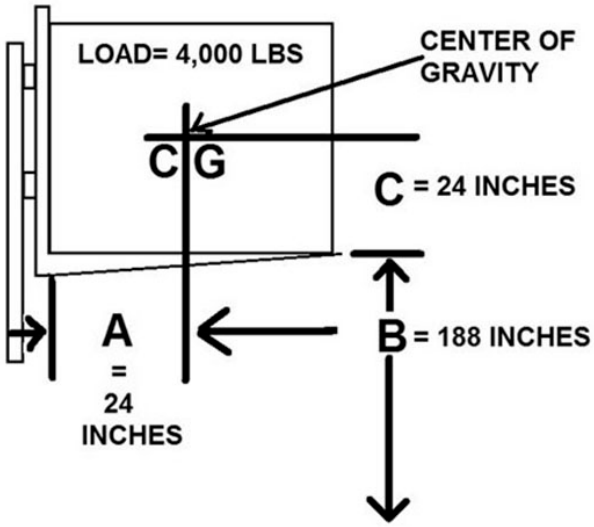


Figure 2–18. Forklift load CG.

Load centering

When lifting and carrying several loads at once, always place the heaviest load against the back of the forks. Placing the heaviest loads near the back of the forks shifts the load center closer to the front wheels and makes for a more stable load. Also, tilting the forks back increases the stability of the load.

Forklift safety

As a pavements and construction equipment operator, you should always practice operational risk management (ORM). The five steps are to identify the hazards, assess the hazards, make risk decisions, implement controls, and supervise safety procedures. Along with using common sense, follow these procedures to ensure safe operations:

- Never approach a load to be lifted with anyone standing in front of the load.
- Never stand or walk under forks or any elevated part of the forklift.
- Only the operator is allowed to ride on the forklift.
- Always keep your legs and arms inside the canopy of the forklift.
- Maintain a safe distance from the edge of any dock, elevated ramp, or platform.
- Only use forklifts for their intended purpose.
- Always set the brakes and chock the wheels to prevent movement of trucks and trailers when loading or unloading.
- Always ensure sufficient headroom under overhead installations, lights, pipes, sprinkler systems, and so forth.
- Always secure the load to the forklift when carrying bulky loads or traveling long distances.
- Cross railroad tracks diagonally when possible.
- Grades will be ascended or descended slowly.
- Forklift will be operated with the load upgrade when the grade is in excess of 10 percent.
- The load will be tilted back and raised to clear the road surface.

Fork attachment

On some AF front-end loaders, the buckets have quick-disconnect carries which allow the buckets to be swapped out for forks. Loaders that can also be used as forklifts are efficient and save the AF money. Refer to the previous unit where we discussed removing attachments on the front-end loader. Figure 2–19, views A, B, and C shows attaching a typical set of forks to the front-end loader.

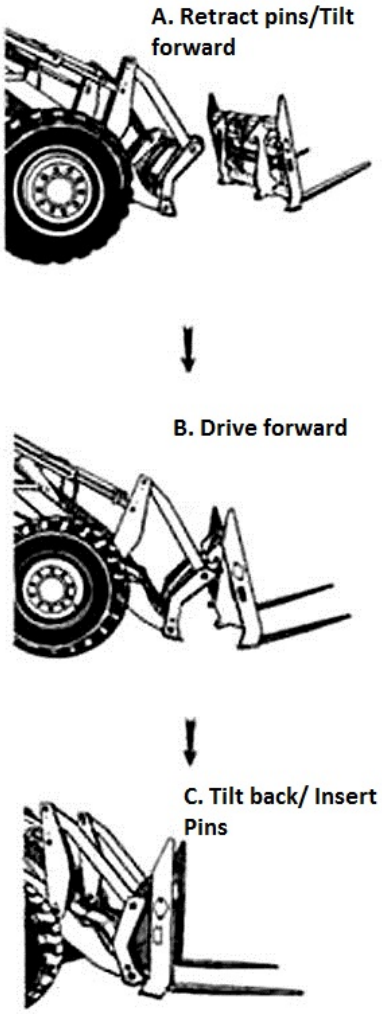


Figure 2–19. Forklift attachment.

10K AT forklifts

We use this AT or RT forklift to load and unload materials from all types of military transport equipment such as trucks, trailers, aircraft, railroad cars, landing craft, and ships. More importantly, we can use them on unstable surfaces, RT, sand, snow, and mud. Unloaded, we can move it at a high speed between job sites.

The 10K AT forklift is designed for outdoor use in uneven or muddy locations. It has pneumatic tires, typically diesel-powered, constructed on the same platform as typical front-end loaders, and operates the same, meaning that the basic operations of the forklift to include lift, lower, tilt, and curl functions operate the same way. Most models have an enclosed cab with heating and cooling capabilities. As the name states, the capacity of a 10K AT forklift is 10,000 lbs at 48-inch load center and can lift the load to a maximum height of 121.6 inches (10 ½ feet). These forklifts also have three speed ranges in both forward and reverse. The forks can be rotated and/or shifted left or right, spread or closed hydraulically, and can be tilted rearward or forward.

Major components

Take a look at figure 2–20 for the location and description of the major components as you read about them below:

1. ENGINE—these types of forklifts have a four-stroked turbocharged six cylinder diesel engine.
2. FUEL SYSTEM—consists of an air cleaner, fuel tank, fuel filters, quick start kit, fuel injection pump, and fuel injectors.
3. EXHAUST SYSTEM—consists of the muffler and exhaust pipe; the muffler is mounted on top of the engine and is a spark arresting type.
4. HYDRAULIC RESERVOIR—consists of a tank for hydraulic fluid and a relief valve.
5. STEERING SYSTEM—consists of the steering wheel, steering gear, two steering cylinders, torque converter-driven steering pump, and ground-driven steering pump (which operates in the event of engine failure).
6. HYDRAULIC LIFT SYSTEM—includes the control valve, boom assembly, hydraulic reservoir, and cylinders (tilt, lift, rotation, side shift, and fork position).
7. ELECTRICAL SYSTEM—is a 24-volt, negative ground. It includes an engine-driven alternator, starter motor, instrument panel, light system, and two 12-volt batteries connected in series.
8. COOLING SYSTEM—includes a radiator mounted in the rear of the forklift, thermostat and housing, engine-driven water pump and fan.

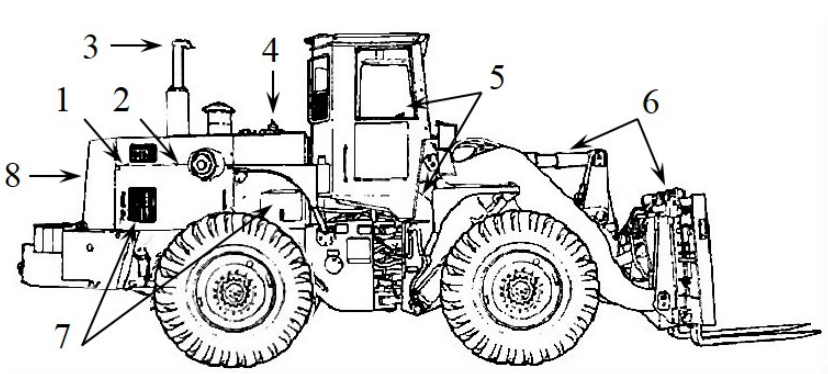


Figure 2–20.10K AT forklift major components.

Additional features

Since this is the larger size of this type of forklift, there are added safety features installed to help minimize operational hazards. The additional safety features are as follows:

- BACKUP ALARM—this is a safety feature that notifies anyone behind the forklift to clear the area. It automatically sounds when the gear selector is put in reverse.
- BOOM PROP—this is mounted on the front main frame between the front wheels. It is to be used to support the boom anytime someone is working beneath the boom.
- MASTER DISCONNECT SWITCH—usually located on the left-hand side of the forklift, this is the master battery switch, always turn this off when finished operating the forklift.
- PARKING/EMERGENCY BRAKE—is located inside the cab near the steering wheel and should be set anytime you leave the cab of the forklift.

Shifting transmission gears

10K AT forklift transmissions typically have three forward and reverse gear ranges, as well as neutral, which are manually selected using the gear range and direction levers. First gear (1) is the lowest and main working gear range. Second gear (2) is the medium range and third gear (3) is used for longer distance travel on roads.

Never shift the transmission into neutral when traveling up or down inclines or declines. You can lose control of the forklift.

Steering

Most 10K AT forklifts have steering that is articulated and is carried out by hydraulic power, which pivots the main frames at the center hinge much the same as a typical front-end loader. You turn the steering wheel until reaching the desired angle of turn. Hydraulic power holds the angle of turn until the steering wheel is turned again.

Fork carriage operation

The fork controls are very similar to other forklifts; so let's describe the components to operate the fork carriage.

Lift control lever

This is the first lever to the right of the operator's seat. It has three control positions: RAISE, HOLD, and LOWER.

- RAISE—pull the lever back until the desired height is reached. Return to HOLD is automatic when the lever is released.
- HOLD—the forks remain at height allowed when the lever is placed in HOLD.
- LOWER—push the lever forward until the desired height is reached. Return to HOLD is automatic when the lever is released.

Tilt control lever

This is the second lever to the right of the operator's seat. It has three control positions: TILT BACK, HOLD, and TILT FORWARD.

- TILT BACK—pull this lever back until the desired upward tilt angle is reached. Return to HOLD is automatic when the lever is released.
- HOLD—the forks remain stationary at angle attained when the lever is placed in HOLD.
- TILT FORWARD—push the lever forward until the desired downward tilt angle is reached. Return to HOLD is automatic when the lever is released.

Side shift, oscillate and fork-positioned control lever

This is the third lever to the right of the operator's seat. Together with the attached mode selector switch, it has nine fork control positions. Using these controls will give you precise control of the forks to make operations more efficient as you don't have to move the machine to orient the forks for the perfect position.

463L air cargo handling system capability

The entire Department of Defense (DOD) airlift system is built around the 463L air cargo handling system. The 463L refers to the standardized pallet used for transporting military cargo in aircraft. These pallets are capable of holding up to 10,000-lbs of cargo. They are built of a balsa wood core and surrounded by a thin aluminum skin. Unlike the smaller wooden pallets found in commercial use, the 463L pallets are flat and smooth on the bottom. This design makes for quicker loading and unloading from aircraft since planes designed to hold the 463L pallets have small rollers on the floor of the aircraft. This means when 463L pallets are placed on the ground, there needs to be dunnage placed underneath the pallet so the forks can easily slide under the 463L pallet. Dunnage or shoring is typically a 4" X4" X88" piece of wood or plastic lumber. Three pieces of dunnage are required to be placed under the 463L pallet. The 10K AT forklift has been designed to transport 463L pallets, and most makes and models are configured very similarly.

The 463L forklift simply has longer forks to accommodate the large aircraft pallets. A forklift not compatible with these pallets has markedly shorter tines and may have trouble picking them up.

An example would be some forklift attachments for front-end loaders. They are shorter in length and have trouble lifting 463L pallets, especially when heavily loaded, or when the load is off center.

Extendable boom forklift

Another type of forklift (F/L) you may be able to operate is called the extendable boom or (boom shooter) F/L. They come in many sizes and configurations and are one of the most versatile pieces of equipment on a job site. They can reach extremely high (in comparison to their overall size) and are RT capable. They can replace small cranes or other such lifting devices because the boom extends as high as two stories or more depending on the model.

Boom shooters will have a load chart which must be strictly adhered to due to its potential for tipping when the boom is fully raised. Most models have outriggers which can be set to add to its stability. If your unit has a boom shooter, get familiar with its operating characteristics and the load chart (fig. 2–21).

Figure 2–21. Extendable boom forklift.

213. Forklift operations

Prior to moving anything with a F/L, make sure you know the capacity of the F/L you are using and the weight of the item to be moved. Check for a data plate or the shipping documents to determine weights. If you can’t find the actual weight, try and estimate the weight using what the item is made of as a reference. You can also use estimating tables of common materials.

No matter which F/L you use when moving material stacked on a pallet, slowly approach the pallet and check the forks to make sure that they are far enough apart to ensure load stability. Also, make sure the forks are low enough so you don't run them through the load on the pallet. If visibility is limited, have a spotter assist you in placing and moving the load. Pull forward and slide the forks under the pallet (fig. 2–22). After the forks are under the pallet, engage the clutch cutout. Accelerate slightly and pull back on the lift control to raise the load; then pull back on the tilt control to keep the load from tipping forward. Remember, when operating a loader with forklift attachment, the tilt control lever for the forklift attachment is the same as the bucket-control lever.

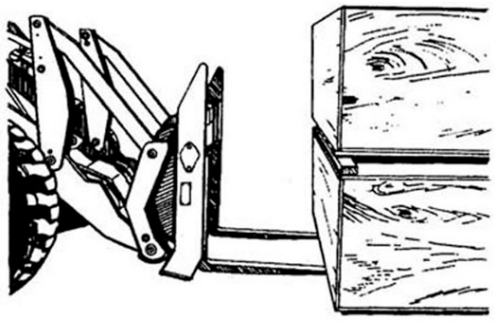


Figure 2–22. Positioning of forklift.

When transporting a load, raise it 12−18 inches off the ground to clear any obstacles. To ensure stability; travel slowly, avoid sharp turns, and don't stop suddenly. Secure the load appropriately if it is bulky or unstable on the forks. If the load makes it impossible to drive safely, turn around and drive backwards. Be very careful as limited visibility around your load can create extremely hazardous conditions.

As you approach the trailer, or whatever it is that you are going to place the material on, decrease your speed and begin elevating the load so it is slightly above the trailer. When you have the load over the trailer, tilt the load forward until it becomes level. Slowly lower the load until it rests on the trailer surface. After the load is firmly on the trailer surface, slowly back the forklift away and proceed to the next pallet to be loaded.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

212. Forklift overview

1. Who is allowed to ride on a forklift?

2. What type of forklift can you use on unstable surfaces?

3. What is the capacity and maximum load height of a 10K AT F/L?

4. Why must you strictly follow the load chart when using a boom shooter F/L?

213. Forklift operations

1. How do you move a load with a forklift when you have poor visibility?

2. What action(s) do you take when approaching the trailer on a F/L?

2–4. Hydraulic Cranes

The crane, with its attachments, is an essential equipment item in the CE inventory. It can perform many important jobs in construction work, day-to-day base civil engineer (BCE) operations, and base recovery activities. Lifting heavy objects, loading and unloading materials and equipment, and excavating are typical jobs performed by the crane. The crane with attachments has a very complex set of characteristics and peculiarities. Consequently, proper and efficient operation of this machine will require more knowledge from you than any other equipment item. You must be especially safety conscious at all times when you operate the crane. To attempt to teach someone everything about cranes in a book is impossible. Therefore, we'll present only enough basic information to familiarize you with the hydraulic crane, some of the attachments, and some techniques for its use.

NOTE: The AF owns several types, sizes, and models of cranes. Although the basic operating procedures are generally the same, you must read and understand the material in the operator's manual before you operate any crane. You must also be sure you understand the particular operating characteristics before actual crane operations. In many cases, personal adjustment will be required when crane size and type varies. The material in this section is for information and training purposes—DON'T CONFUSE THIS INFORMATION WITH THE TYPE OF CRANE ON YOUR INSTALLATION.

214. Crane overview

The RT hydraulic mobile crane is the AF standard. Compared to the mechanical cranes, its operation is smooth and easy. The crane's versatility and ease of operation makes it a useful tool. The AF also has hydraulic truck-mounted cranes, but we will concentrate on the RT crane.

Construction features

The crane is powered by a diesel engine that supplies power to the drive train and a hydraulic system. The hydraulic fluid flow is controlled or directed by the operator through various control levers that engage valves. Figure 2–23 will give you an idea of the construction of a typical crane.

The engine is mounted at the rear of the crane. It powers the crane through a torque converter and typical six-speed (forward and reverse) transmission. Outriggers provide a stable base for maximum lift. The outriggers are separately controlled by hydraulics allowing the operator to level the crane during operations. Because of the design and the chassis size, all outriggers should be used anytime the boom is raised unless requirements necessitate a lift to be made on rubber. The crane is also capable of 360-degree rotation with all crane functions controlled from inside the cab.

Figure 2–23. Hydraulic-operated crane.

Standard crane signals

When operating a crane, there are a set of guidelines that must be used at all times. Let's look at two major areas of safety that will always require close attention before, during, and after crane operation: standard crane signals and power line safety precaution.

It's a standard practice for two people to be assigned to a crane. One is the operator and the other is the helper, ground person, or simply the "rigger." The rigger hooks and unhooks loads, and signals the operator when to lift and lower the load and where to position the load. Standard signals are used for these purposes (figs. 2–24A, 2–24B, and 2–24C). It's important that you and your helper learn and use these signals. Don't attempt to develop or use signals of your own. If you do, you're inviting an accident. Why? If helpers change, the new helper will probably not understand your signal system and will become confused. Confusion leads to accidents. Additionally, the signals depicted below are the national standard and as such must be present on all crane carriers and inside the operator's cap per OSHA.

As you look through the charts, notice that some of the signals don't apply to us. An example is those signals for trolley cranes and tracked cranes. Pay particular attention to the basic signals that will apply to any crane. Also, remember that the forefinger signifies the hoist and the thumb signifies the boom. This will become clearer as to why that is significant later in the lesson.

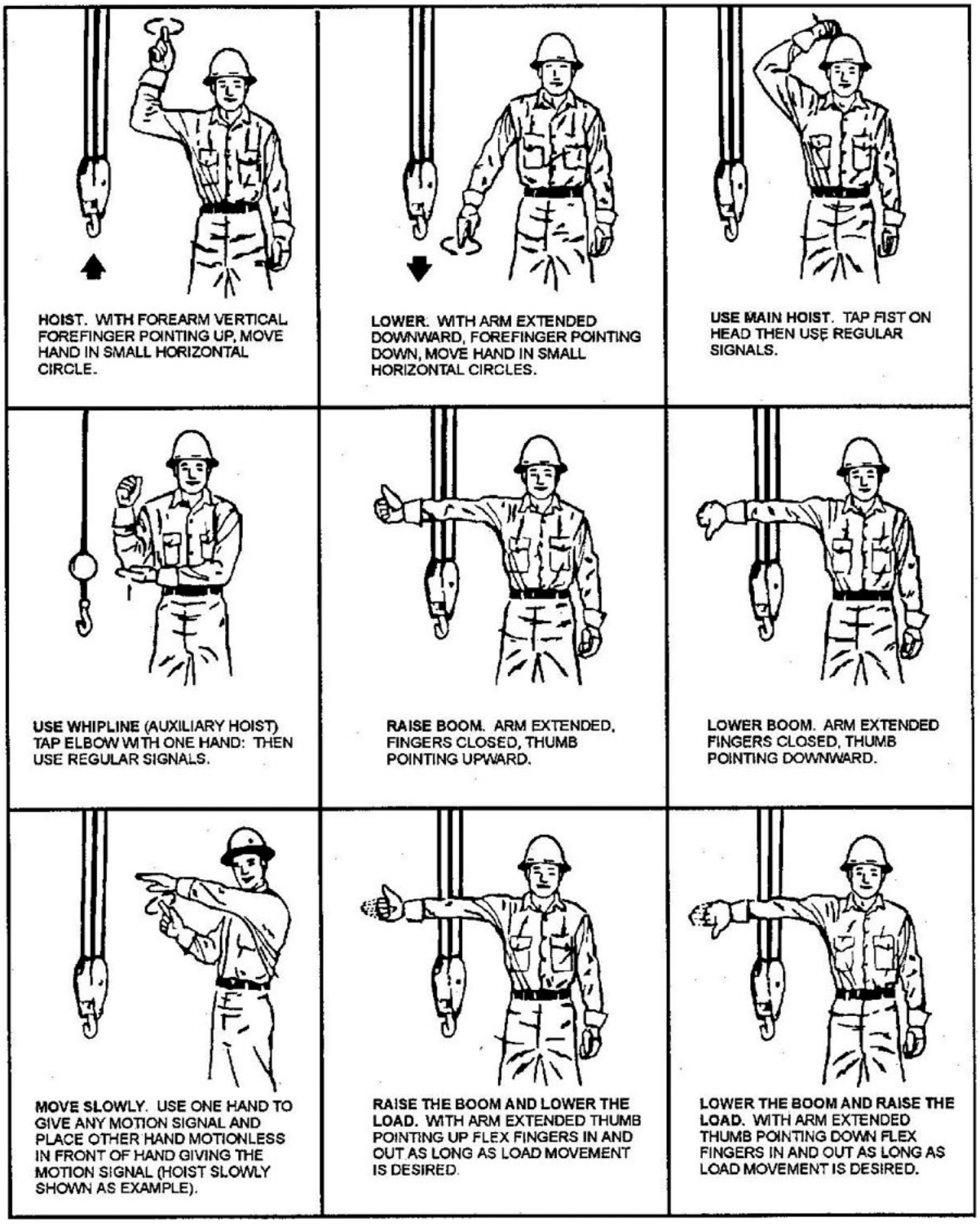


Figure 2–24A. Standard crane signals.

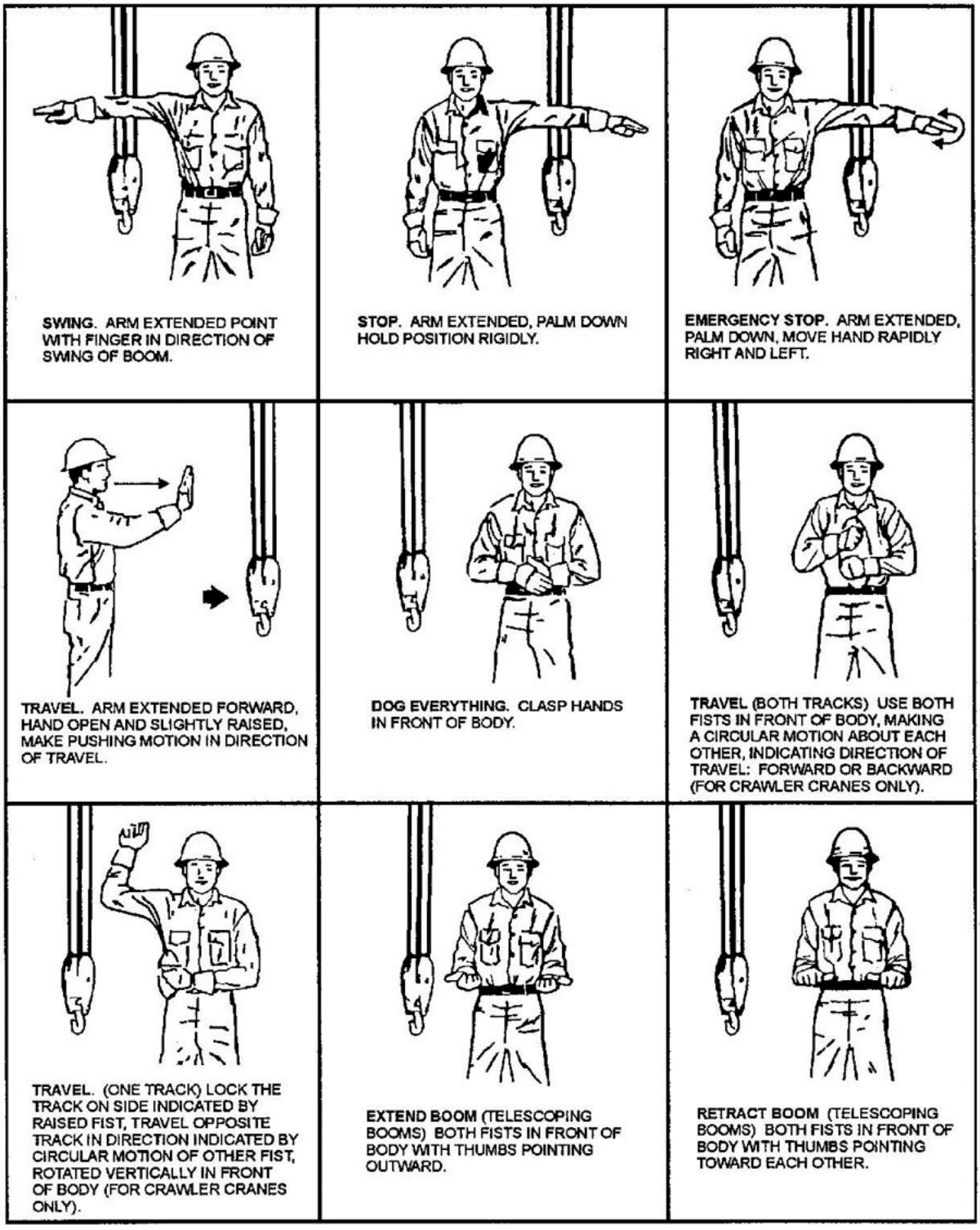


Figure 2–24B. Standard crane signals.

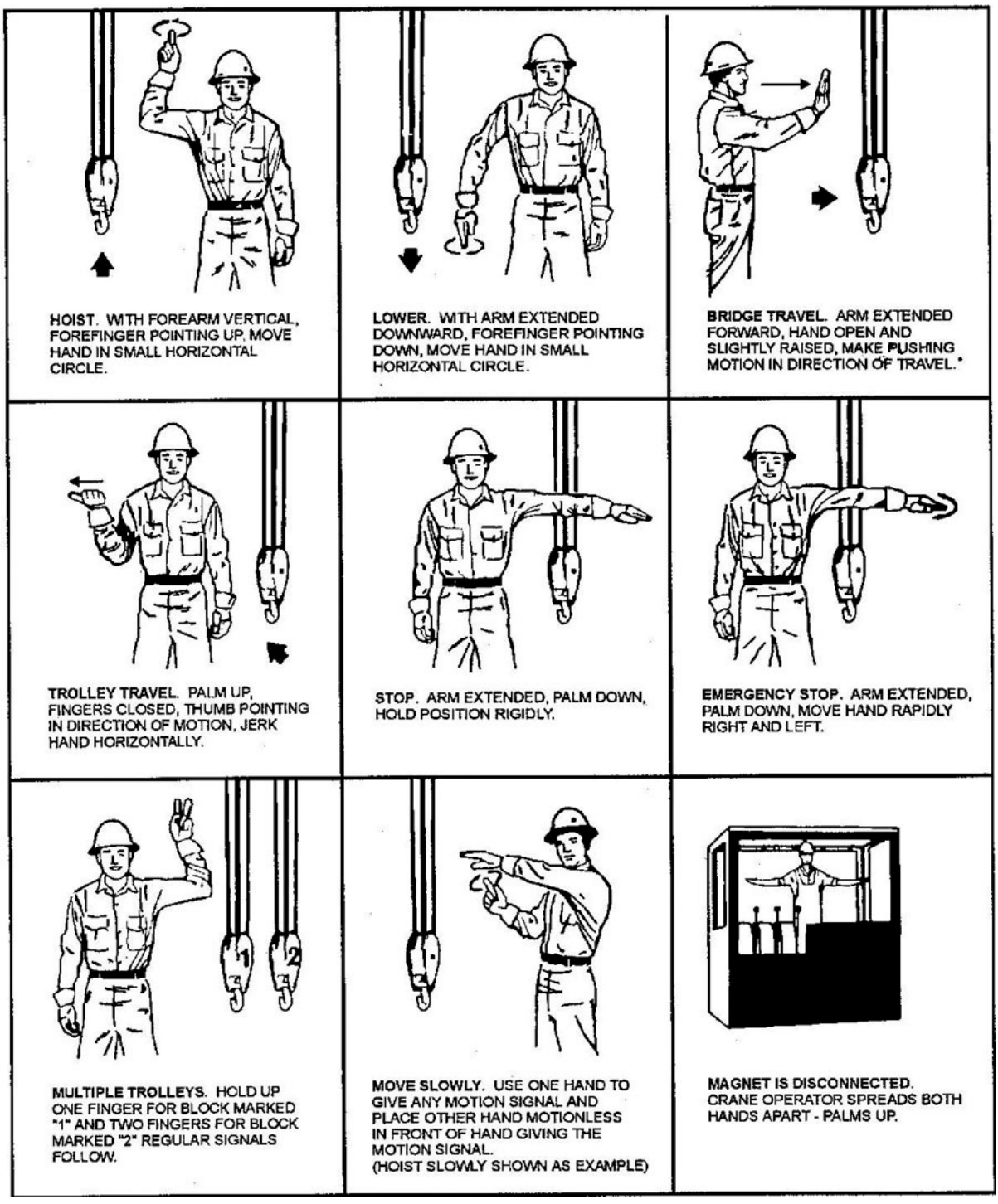


Figure 2–24C. Standard crane signals.

Power line safety precautions

Let's carefully consider the danger of operating a crane near high-tension electrical wires. We know you wouldn't aim a pistol, rifle, or shotgun at a friend, or put your finger in an empty light socket to determine if the current is turned on—so why take a chance of fouling a high-tension line with a crane. As ridiculous as it may seem, every year the United States loses experienced operators because they fail to adhere to this safety precaution. These operators we can't help, but hopefully we can help you by preventing you from taking that one deadly chance.

No part of a crane or its load should come within 10 feet of any live electrical line. To keep this hazard foremost in the operator's mind, a sign, "DANGER – DO NOT OPERATE THIS EQUIPMENT WITHIN 10 FEET OF ELECTRIC POWER LINES," is permanently attached to the crane in full view of the operator. OSHA states that this distance is adequate for electric lines up to 50 kilovolts (kV); however, there should be 10 feet plus 0.4 inch for each one kV over 50 kV. Where it's impractical to adhere to minimum distances and crane operations are necessary in that location, the electric current will be shut off.

If the boom of a rubber-tired crane should contact a hot wire, the entire piece of equipment becomes charged—when possible, it's best for the operator to remain on the crane in situations of this type and wait for the power to be turned off. And let's not forget about the help that's on the ground physically positioning the load. They could become electrocuted if they inadvertently touch a charged crane or load.

When rigging with wire rope or chains and the boom is against a hot line, the rigging and the load (when constructed with conductive materials) become charged; therefore, these safety precautions apply to helpers as well. Use nylon rope or a nonconductive pole to position a load when working near high-tension electrical lines.

Your crane may also have an electrical boom shield mounted to the boom tip section called a dielectric boom shield. This mounting location allows the boom shield to be removed with the tip section if additional boom sections are needed (truck-mounted only). The shield also guards the boom from coming in contact with power lines. The boom shield is installed with insulators to prevent the conduction of electricity.

General safety precautions

Workers outside the crane must wear approved hard hats whenever they are in the work area of the crane. They must also wear gloves and safety toe boots when working with wire rope and rigging. When setting up the crane, it is a good practice to cordon off the entire work area of the crane so no unauthorized person inadvertently walks into the area. This area represents 360 degrees around the crane where the load could possibly be. Set up cones or flagging tape, so there is no question as to where the work area is and make sure no person comes into it.

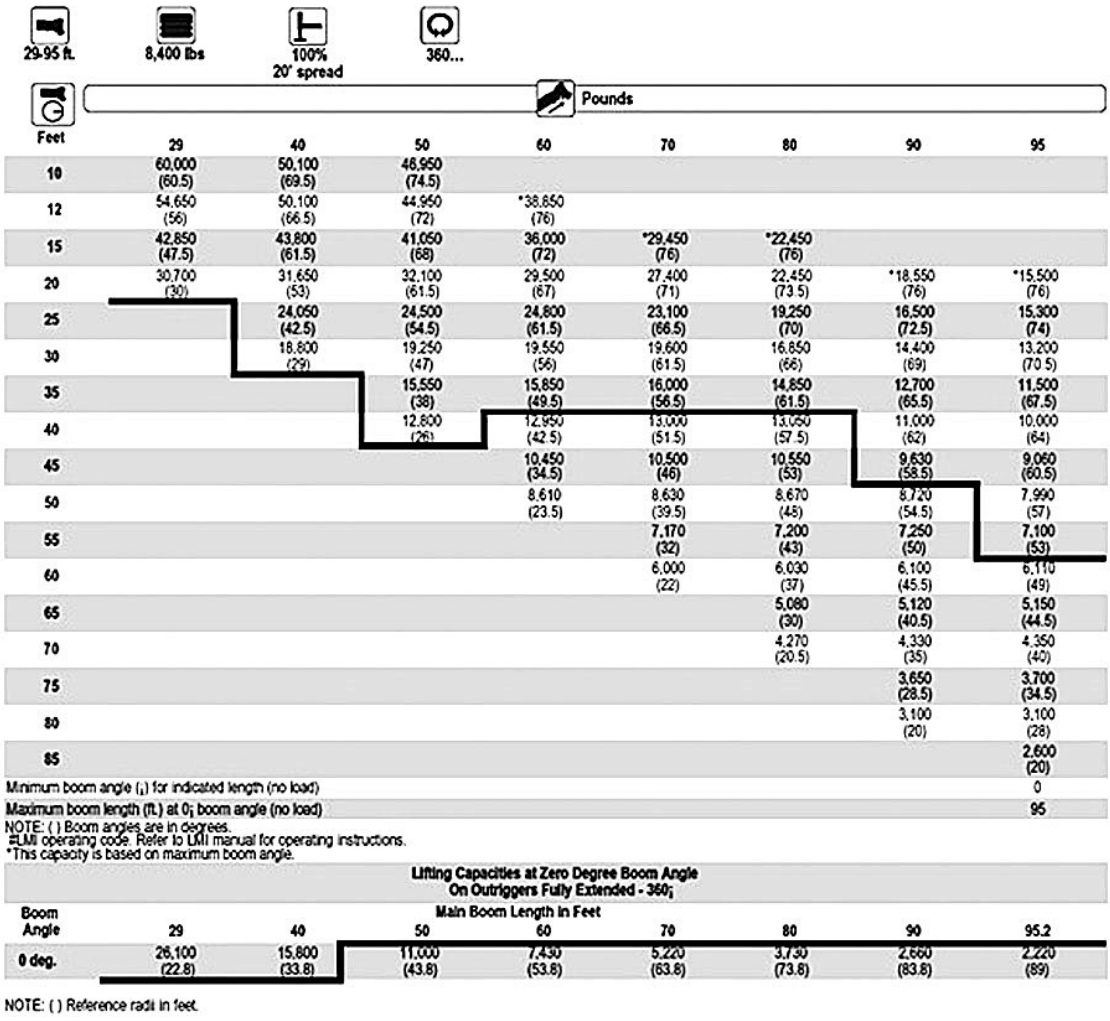
Individuals working with the crane (to include the operator and the ground personnel) should go over the hand signals prior to starting operations. If the lift is going to be "blind" (a situation where the operator can't see the load as it is being set, or lifted) establish communication before the lift. Radios can be used successfully for these types of lifts.

Load charts interpretation

Before any lifting operation, an operator must know the lifting capacity of the crane that will be used and the weight of the item being hoisted. Additional items added to the weight include the hook block, load handling devices parts of line and any other items listed in on the load chart (in the manual) that are required to complete the assigned tasking. Adding all these weights together will factor with the radius, boom length in feet, and angle/degree that is required to lift an item as started earlier. Load charts will provide the information to determine if the job can be done with the type crane your section may have.

The standard crane that the AF uses has several load charts to include: on outriggers 100 percent, on rubber (tires), with the boom extension (jib) employed, with or without counterweight, and many others. There may be a separate load chart for the many different ways you can configure your specific crane. Get acquainted with your crane's specifics and know the load chart.

We will discuss the two most common load charts here: on outriggers 100 percent and on rubber. Look at figure 2–25 which illustrates a typical load chart with outriggers fully extended (100 percent), 8,400 lbs of counterweight and 360 degrees of rotation for a RT crane. Additionally, we will discuss the factors that make up that chart and how to read it.



Feet	29	40	50	60	70	80	90	95
10	60,000 (60.5)	50,100 (69.5)	46,950 (74.5)					
12	54,650 (56)	50,100 (66.5)	44,950 (72)	*38,650 (76)				
15	42,850 (47.5)	43,800 (61.5)	41,050 (68)	36,000 (72)	*29,450 (76)	*22,450 (76)		
20	30,700 (30)	31,650 (53)	32,100 (61.5)	29,500 (67)	27,400 (71)	22,450 (73.5)	*18,550 (76)	*15,500 (76)
25		24,050 (42.5)	24,500 (54.5)	24,800 (61.5)	23,100 (66.5)	19,250 (70)	16,500 (72.5)	15,300 (74)
30		18,800 (29)	19,250 (47)	19,550 (56)	19,600 (61.5)	16,850 (66)	14,400 (69)	13,200 (70.5)
35			15,550 (38)	15,850 (49.5)	16,000 (56.5)	14,850 (61.5)	12,700 (65.5)	11,500 (67.5)
40			12,800 (26)	12,950 (42.5)	13,000 (51.5)	13,050 (57.5)	11,000 (62)	10,000 (64)
45				10,450 (34.5)	10,500 (46)	10,550 (53)	9,630 (58.5)	9,060 (60.5)
50				8,610 (23.5)	8,630 (39.5)	8,670 (48)	8,720 (54.5)	7,990 (57)
55					7,170 (32)	7,200 (43)	7,250 (50)	7,100 (53)
60					6,000 (22)	6,030 (37)	6,100 (45.5)	6,110 (49)
65						5,080 (30)	5,120 (40.5)	5,150 (44.5)
70						4,270 (20.5)	4,330 (35)	4,350 (40)
75							3,650 (28.5)	3,700 (34.5)
80							3,100 (20)	3,100 (28)
85								2,600 (20)
Minimum boom angle (↓) for indicated length (no load)								0
Maximum boom length (ft.) at 0↓ boom angle (no load)								95

NOTE: ( ) Boom angles are in degrees.
≠LMI operating code. Refer to LMI manual for operating instructions.
*This capacity is based on maximum boom angle.

Lifting Capacities at Zero Degree Boom Angle On Outriggers Fully Extended - 360↓

Boom Angle	Main Boom Length in Feet 29	40	50	60	70	80	90	95.2
0 deg.	26,100 (22.8)	15,800 (33.8)	11,000 (43.8)	7,430 (53.8)	5,220 (63.8)	3,730 (73.8)	2,660 (83.8)	2,220 (89)

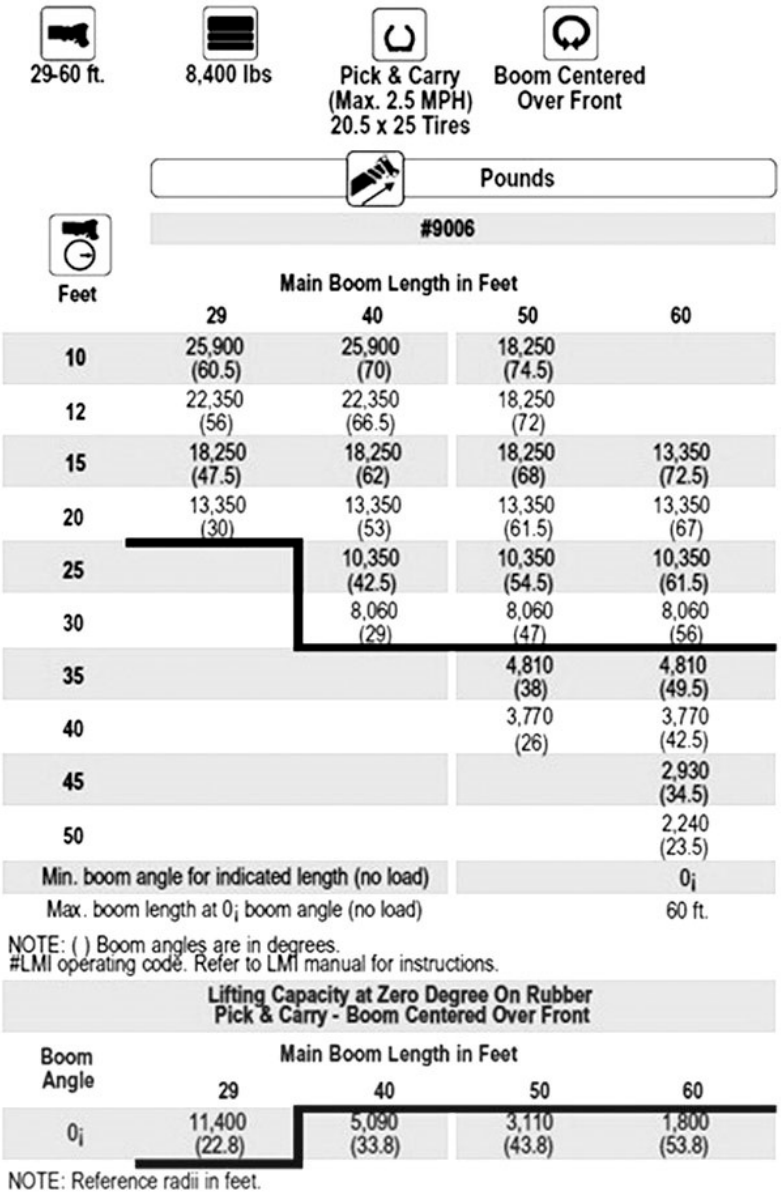
NOTE: ( ) Reference radii in feet.

Figure 2–25. Typical crane load chart.

Looking at the chart, you see *radius in feet* on the left side of the chart. *Radius in feet* refers to the horizontal distance from the axis of rotation to the tip of the boom. Next is *boom length in feet* across the top of the chart, which means how much boom is extended from its fully retracted measurement (29 feet in this case). The number in parentheses ( ) under each capacity refers to the angle of the boom from the horizontal plane of the crane. The *bold line* across the load chart represents *stability and structural capacities* of the crane. Above the bold line represents stability which simply means if the load is lifted over the weight allowed for the angle/radius/boom length per the load chart, the crane may tip over. Capacities below the bold line represent the possibility of structural failure when lifting items above the allowed weight of the given parameters (radius, boom length, and boom angle). This basic information will be a major part in determining how much, how far away from the crane (radius/boom length), and how high (angle/degree) an item can be lifted with the crane.

You must know how you are going to move the load and how each movement will affect the crane's capacity. For instance, if you are well within your capacity to lift an item, but need to move the item out away from you (increase in radius), your capacity will decrease. Whenever you boom down, the arc created moves the load away from you, thus increasing the radius. Similarly, if you boom out your radius will also increase. You must know acceptable capacities within the full-range of movement (from where you pick the load to the place where you set the load) of the load.

Sometimes a crane operator may be required to make lifts without the outriggers, which is also known as *on rubber*. Looking at figure 2–26 we can see much of the same information as before when lifting on outriggers, but the capacities are reduced considerably. Tire size on the crane also plays a major factor when planning to make a lift with the crane as the size is specific to rated capacities. The chart also shows speeds allowed if the crane is used to transport an item over paved and non-paved surfaces (pick and carry). As mentioned earlier, only conduct lifts on rubber if absolutely necessary.



29-60 ft. | 8,400 lbs | Pick & Carry (Max. 2.5 MPH) 20.5 x 25 Tires | Boom Centered Over Front

Pounds

#9006

Feet	Main Boom Length in Feet 29	40	50	60
10	25,900 (60.5)	25,900 (70)	18,250 (74.5)	
12	22,350 (56)	22,350 (66.5)	18,250 (72)	
15	18,250 (47.5)	18,250 (62)	18,250 (68)	13,350 (72.5)
20	13,350 (30)	13,350 (53)	13,350 (61.5)	13,350 (67)
25		10,350 (42.5)	10,350 (54.5)	10,350 (61.5)
30		8,060 (29)	8,060 (47)	8,060 (56)
35			4,810 (38)	4,810 (49.5)
40			3,770 (26)	3,770 (42.5)
45				2,930 (34.5)
50				2,240 (23.5)
Min. boom angle for indicated length (no load)				0_i
Max. boom length at 0_i boom angle (no load)				60 ft.

NOTE: ( ) Boom angles are in degrees.
#LMI operating code. Refer to LMI manual for instructions.

Lifting Capacity at Zero Degree On Rubber
Pick & Carry - Boom Centered Over Front

Boom Angle	Main Boom Length in Feet 29	40	50	60
0_i	11,400 (22.8)	5,090 (33.8)	3,110 (43.8)	1,800 (53.8)

NOTE: Reference radii in feet.

Figure 2–26. On rubber load chart.

Creep is a motion for less than 200 feet in a 30 minute period and not exceeding one mph. The top speed is two and one-half mph to move a load with the crane in this type mode of operation. If the crane must be used to transport the items over a short distance, it will be over the front of the crane with the boom at six degrees angle or less only.

NOTE: The load chart information given in the lesson is just part of the training you will be required to know before making any type of lift with a crane.

Boom extension

A boom extension or "jib" can be employed to add to the overall length of the boom. They are used for reaching extremely high points where the capacity is relatively low. An example of when a jib would be useful, is when you are setting relatively light structural steel for a long building and don't want to have to continually reset the crane. Simply deploy the jib and gain an extra 20–30 feet of boom length. The boom extension is usually stowed along the side of the crane and is retained by a series of pins.

Simply unpin the jib and swing it into place at the boom tip. Once in position, pin it in its new location. In most instances, when there is a jib present, there is also a high-speed hoist reel available with which you will string a single line. At the end of this single line will be a weighted hook, sometimes called a "headache ball." Because of the reel's high speed, using it in conjunction with the jib is a very quick and efficient way to lift materials up high.

Hook-block

Hook-blocks come in all different sizes, capacities, and number of reeves (sheaves within the hook-block). The hook block is what the load attaches to and is an integral part of the crane and as such is determined by the capacity of the crane. If the crane is rated at 15 tons, the hook-block will be rated at the same (30,000 lbs). If you have a mismatched block, refer to the owner's manual for the correct one.

The number of reeves (the number of times the wire rope enters the block and its corresponding sheaves in the boom tip) designates the number parts-line of the setup, but does not increase the crane's capacity. The boom and crane carrier can only handle just so much weight (its capacity), and adding more lines will only make the main winch work less (due to the mechanical advantage of the multiple reeves) as well as, make it work much slower (many more feet of line to make the load travel the same distance); however, slowing the line down would enable you to make more precise movements, and the crane would not have to work as hard. Information on the hook-block is contained in the operator's manual.

215. Operating a crane

You can use a crane to lift and load large items like portable generators and air conditioning units. You can also use a crane to set up various towers, lift and load small downed aircraft, place structural steel for steel frame buildings, or load and unload railroad cars. In fact, a list of items that you may be called upon to lift with a crane would be almost endless. In a true sense, you can use a crane to lift almost anything that you can't lift with your hands. It's important you keep in mind that whatever the load, there's a definite procedure for inspecting, lifting, swinging, and positioning the load.

Inspecting

Before a crane is ever operated, an inspection must be completed, but this will not be the only time the crane will be inspected! There are several types of inspections required (initial, periodic, frequent, and preop), and a crane operator must know what type and when each inspection must be completed.

Initial inspections

Initial inspections are applied to new or altered cranes and will be performed by a "qualified inspector" as designated by the crane owner, usually a certified contractor that is allowed to do such inspections. Every initial inspection will include a load test to verify the crane's structural integrity ratings. Load tests are required anytime the crane's structure has to be repaired. A load test will not be less than 100 percent and not more than 125 percent of the crane's rating. Upon completion of the load test, the load test date will be stenciled on the boom.

Periodic inspections

Periodic inspections are regularly scheduled on a monthly, quarterly, or annual basis but not to exceed annually. The crane owner, based on the cranes usage, determines the inspection intervals.

These inspections may be carried out either by a qualified operator or inspector depending on the length of the interval and the intensity of the inspection.

Frequent (preuse) inspections

Frequent inspections will be performed daily before its use, during operation, or at the beginning of each shift as the operator deems necessary. A strict program of preventive maintenance, daily service, and thorough preop checks will result in properly operating, safer equipment, and lower operating costs.

Preop (daily) inspections

It's your responsibility as an operator to know the condition of your equipment and not to knowingly operate any crane or equipment that is unsafe or hazardous. Inspecting cranes or similar equipment requires considerable skill and knowledge, and it's your responsibility to obtain that knowledge. If the information or procedure is unclear, ask someone. Having a good understanding of crane inspection is just the start of knowledge required to become a crane operator.

Lifting

Before lifting, be sure to check the weight of the load against the load chart in the cab. Doing this will prevent you from exceeding the lifting capabilities of the crane. After you've determined the weight, make sure that you do the following:

- Outriggers are firmly positioned on solid surfaces.
- Crane is leveled.
- Brakes are set.
- The load is properly rigged and attached to the hook-block.

NOTE: The importance of properly leveling a crane can't be overstressed. A crane that's only slightly out-of-level can quickly encounter a tipping condition. Lift the load slightly off the ground and recheck the stability before proceeding with the lift. If you should encounter a tipping condition, start lowering the load with the hoist line and retract or elevate the boom to bring the load in towards the machine (reduce the radius). NEVER lower or extend the boom, this will only aggravate the condition.

Accident causing conditions

Most accidents involving mobile hydraulic cranes are caused by the following:

- Crane out of level.
- Bad surface conditions.
- Outriggers used improperly or not used at all.
- Improper crane operation.

Working area

The working area represents 360 degrees around the crane and can be broken into quadrants (over the front, over the rear, and over the side). Depending on the type of crane and how it is configured, the rated capacities could be different depending on which area you are working in. The load chart depicted in figure 2–25 had a working area of 360 degrees. The load chart in figure 2–26 (on rubber) significantly reduces the working area as pictured in figure 2–27.

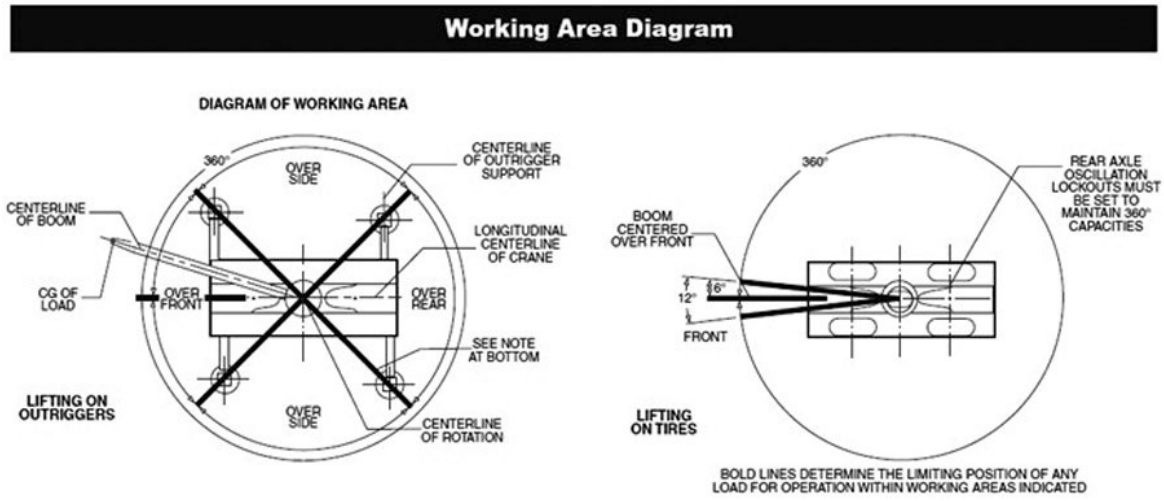


Figure 2–27. Working area diagram.

Lifting procedure

The first step in a lifting operation is to thoroughly plan the lift. You must know the weights and capacities, the range of movement, and where you will be setting up. If conducting a “critical” lift (one in which the crane’s capacity is reached) planning becomes essential.

Once you have planned and are set up level and on firm footing, position the boom. To do this, pull back on the boom lift lever and raise the boom. If you happen to get the boom a little too high, push the boom lift lever forward. Once you return the boom lift lever back to the neutral position, the boom will stay at that position. To extend the boom, push the telescope control lever forward away from you. Hold the control in the OUT position and hold it there until the boom extends to the desired length. To retract the boom, pull back on the telescope control lever until the boom retracts to the desired length. Always keep the boom as short as possible because it will be easier to control the load and your capacities are greater.

The next step is hoisting the load. To do this, attach the hook-block to the load. To raise the load, pull the slow-speed hoist drum lever back. When you start to lift the load, lift slowly and proceed with caution. Raise the load a few inches off the ground and stop. Check your level and then check your computer (if equipped with one) to make sure you are within the parameters and everything seems stable.

Load estimation

Load estimation is the process used to calculate the weight of the load. In the case of crane operations, load estimation relates to the weight of the load being moved by the crane. Most of the time, it is thought that load estimation would only be conducted if you the operator are unaware of the actual weight of the load to be moved. This thought is inaccurate. The load includes the weight of the item(s) to be lifted and all of the gear being used to rig the crane to the load. Every item that is below the hook block is included in this measurement. So, load estimation will be conducted even if the weight of the object to be loaded is clearly stenciled on the side of its container.

The load estimation is conducted before any equipment is actually brought to a site where the load is located. Calculations are needed so operators will know such things as the size and capacity of the rigging equipment, the lifting capacity of the crane, and what size/type of vehicle will be needed to transport the load to its destination if need be. As you can see, load estimations provide important information used during crane operations.

There are many acceptable ways to determine the weight of a load. Some of the more common ones are as follows:

- Data plates—usually affixed to the load.
- Manufacturer's documents.
- Tech manuals.
- Shipping receipts.
- Physically weigh the item.

NOTE: Knowing all of your options can be helpful to prevent having to physically weigh the load yourself. Keep in mind that any load can be altered by extraneous items not included in the methods above. For example, when fluids/ballast/counterweights etc. are added to the equipment, the weight of these additional items needs to be added to the weight listed on its data plate.

Calculating weight

Every time you are preparing to move a load, you should expect to know the weight of that load. To accurately calculate this weight, you will need to use certain formulas. When calculating weight you will need to know the objects area, volume, and the weight of the material itself being lifted to accurately calculate the overall load weight.

There are three basic principles to follow when calculating weight: *always* round up, *never* mix feet and inches, and double check your answers!

Find the area

The most basic formula used will be for a square or rectangular load, which is:

Area (A) = Length (L) x Width (W), or simply A = L x W

Let's assume you need to find the area of an object that is 16 feet long and 7 feet wide, this information will be plugged into the equation to calculate the overall area.

A = L x W
A = 16 x 7
A = 112 ft^2

Both of these measurements are in "feet." Therefore, the Area is also measured in "feet." Specifically, when the length and width are multiplied together, then the Area is measured in "square feet (ft^2)."

Find the volume

To calculate the weight of the object (fig. 2–28) you need to calculate all 3 dimensions by using this formula:

Volume (V) = Area (A) x Height (H); or simply V = A x H

For simplicity use the same object you used when measuring area to determine its volume. That object having a length and width of 16 feet and 7 feet respectively. Now you must add the third dimension of height (or depth), here we will use 10 inches.

Using one of the three basic rules, we *never* mix feet with inches. The standard unit of measure for determining weight is "feet." Meaning any measurement in inches must be converted into feet by dividing the number of inches by 12. For example:

10 inches ÷ 12 = .83333

Remembering to round all answers to the nearest hundreds place, the formula now becomes:

V = A x H
V = 112 ft^2 x .83
V = 92.96 cubic feet or ft^3 (rounding up)
V = 93 ft^3

When measuring different dimensions just remember:

1 dimension = measured in feet

2 dimensions = measured in square feet (ft^2)

3 dimensions = measured in cubic feet (ft^3)

Determine the materials weight

Remember that you as the operator make these calculations to determine the overall weight of the material being lifted. To determine weight, you need to know the characteristics of the material. Some material weighs more than others. For example, a stack of plywood that is 4 feet in height weighs nowhere near the same as the same height of steel plates. Below in figure 2–28 is a condensed version of a material data sheet; this data sheet should be kept in the crane to help calculate the weight.

Material	Weight per ft^3	Material	Weight per ft^2 per inch of thickness
Oak	50 lbs	Aluminum	13.75 lbs
Sand (dry)	105 lbs	Steel	40.8 lbs
Aluminum	165 lbs	Brass	44.5 lbs

Figure 2–28. Material data sheet.

For this example, the object being lifted will be a block of aluminum. Using the volume already calculated previously (93 ft^3) we must determine the materials weight. Knowing the material is made of aluminum you can reference the material data sheet, and according to the data sheet you can see that aluminum weighs 165 lbs *per cubic foot*.

NOTE: The measurements contained in material data sheets apply to materials that are dry. So, if an operator needs to lift a load of lumber that has been soaked in water from a recent rain storm, they need to realize the measurements in the material data sheets are too light. In this case, the operator will have to come up with a way to actually weigh the material before attempting to lift it. Failing to take this precaution could lead to overloading the crane and rigging gear resulting in damage to equipment and possible injury to personnel.

Calculate the weight of the load

To calculate the weight of the object, recall the volume of the material has been found to be 93 ft^3. The weight of the material (aluminum) has been found to be 165 lbs per ft^3. The operator finds the weight of this block of aluminum by multiplying the volume of the material by the material's weight. In this case, the following formula would be:

Weight (W) = Volume (V) x Material (M); or simply W = V x M
W = 93 x 165
W = 15,345 pounds

Lastly, the weight of the lifting gear must be added to the weight of the object to find how much the crane will actually be required to lift. If the rigging and lifting items are without their own data plate, you can refer to the manufacturer's website for information. If the information cannot be found online or in technical manuals, the operator will simply take the gear to a scale and weigh them. Whatever method is used, the operator must find the weight of the gear they will use and add that weight of the material to find the total load weight.

In this case, it will be considered that the rigging weighs 150 lbs. This will be added to the weight of the aluminum which was calculated to weigh 15,345 lbs. adding these together results in a total load weight of 15,495 lbs.

This information will be used to help operators decide what vehicle will be needed to haul this object to its destination. The total weight of the load can also be used in future calculations to determine the size of lifting gear operators will need to make the actual lift.

Swinging and positioning the load

Before you begin swinging operations, make sure the area in the swing path, as well as the tail swing area, is clear of any obstructions. Remove the turntable lock pin (if so equipped). With the area clear, the lock pin removed and stored, you're now ready to swing the crane with its load. To move the load to the right, push the boom swing lever forward. To move the load to the left, pull back on the boom swing lever.

Rotation is stopped when you return the control lever to the NEUTRAL position. This will automatically set the swing brake. Become familiar with the controls of your crane before operating it. Always watch the load and signal person while the load is moving. In case you have to look in another direction or you lose sight of the load or signal person, stop the operation immediately.

Spotting the load requires accurate control of hoist and swing movements. It takes practice to locate the load at the exact spot without hunting or overshooting. You can raise, lower, extend, or retract the boom to make accurate locations of the load (as long as you stay within the parameters of the load chart). If you have to move the crane to position the load, lower the load to the ground, then reposition the crane.

The slow-speed hoist drum lever is used to lower a load. To do this, push the lever forward. When starting or stopping the hoist, don't jerk the control lever. Jerking the lever causes a shock to the load that could result in possible damage to the load or to the crane. Keep in mind to always check the area below the load to be sure it's clear of any obstructions.

Most loads will need to be controlled in a way they can be placed precisely and safely. Even a seasoned crane operator can have trouble keeping a load under control and therefore, the ground person or the rigger will have to step in. We control the load from the ground through the use of guide-ropes or taglines. Taglines are secured directly to the load and help control excessive movement and aid in precise placement. The ground guy should never place a hand on the load due to the hazards involved. Also, the ground guy should never get in between the load and other objects and should never stand under an elevated load. For greater precision, use two ground guys and two taglines. For lifts of great height, make sure taglines are long enough to reach. Keeping the load controlled will ensure a safe work area.

When moving within the job site, or for a few blocks, ensure the boom sections are fully retracted. Swing and lower the boom over-the-front to just above horizontal. After swinging the boom to the front, insert the turntable lock pin. **NEVER** travel with a load attached to the hook-block.

Using the hydraulic crane clamshell

The hydraulic crane is primarily used to lift a load, move it horizontally by swinging, and then lowering or dumping the load in a designated position. In addition to the hook block already discussed, there are many additional attachments available that can be used with the crane. Some newer cranes in the inventory do not come with a clamshell attachment, but it is good information none the less.

Clamshell

A clamshell can be used with the hydraulic crane to excavate, load loose materials into trucks, unload construction materials from railroad cars, and to do other similar jobs. The clamshell bucket has bolted-on digging teeth that are used whenever you must dig. The teeth should remain on the bucket for most jobs; however, you must remove them to unload asphalt, coal, sand, gravel, and so forth, from railroad cars. Also, you must remove the teeth to pick up dirt, gravel, and other like materials from paved areas. The reasons of course, for removing the teeth when you're removing material from

hard surfaced areas, is to prevent damage to the pavement or railroad car floors. Removing the teeth will also aid in doing a cleaner job.

Clamshell conversion

The attachments for the clamshell include the following:

- Bucket.
- Combination hose.
- Tagline reel mounted on the boom.
- Separate fairlead assembly. This assembly is mounted on the lower part of the boom and consists of two rollers and two sheaves in a frame.

When you're attaching the clamshell, follow these procedures and reference figure 2–29:

1. Retract and lower the boom so it's in a HORIZONTAL position with the boom tip over the clamshell bucket.
2. Reeve a single part hoist line up, over, and through the boom tip.
3. With a wire rope socket attached on the hoist line, drop the line down, and attach it to the top link of the clamshell.
4. Attach the tagline wire rope from the reel mounted on the boom to the center of the clamshell bucket.
5. Using the quick-disconnects, connect the hoses from the reel to the matching hoses on the clamshell bucket.

After you've assembled the clamshell and made all the correct adjustments, the tagline wire rope should carry the load between the clamshell and the reel. The hydraulic hoses shouldn't carry any of the load, but they shouldn't be excessively slack either.

Clamshell operation

After the clamshell has been installed, the next step is the operation. When you want to raise and lower the bucket, use the main hoist lever. To lower the bucket push the lever forward, to raise the bucket pull the lever back. To maintain control, operate the engine around half throttle. Move the lever slowly when raising and lowering the wire rope to prevent back-lashing the wire rope on the drum.

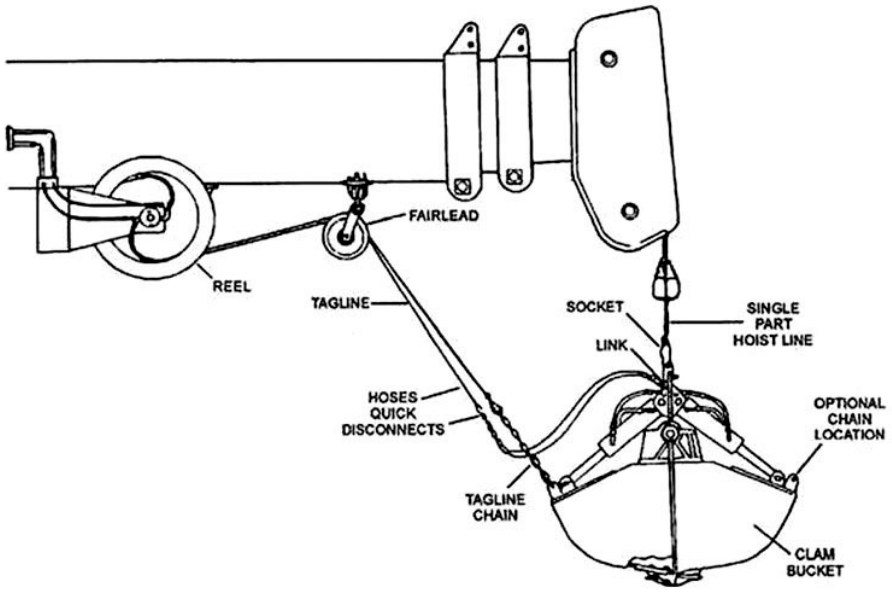


Figure 2–29. Clamshell bucket.

When you want to open and close the bucket use the clam lever. Push the lever to open the bucket and pull back to close. When the bucket closes, some wire rope slack may be created. You can take up this slack by pulling back on the hoist lever. Always maintain some tension on the hoist wire rope, so the wire rope will wind properly on the drum and avoid the potential for "bird nesting."

When you have the boom raised to the desired angle (roughly 45 degrees), raise the clamshell to about a foot above the material. When you get the clamshell to the desired height, swing it over the material to be worked. Lower the clamshell into the material to be loaded. Close the clamshell by pulling the clam lever backward. When the bucket is filled, release the lever. As the bucket rises above the material being worked, start swinging toward the dump point. If you're loading material into a truck, position the loaded clamshell over the center of the truck bed. You do this by raising or lowering the boom or by having the driver position the truck. It's usually better to have the driver position the truck. This keeps you from raising and lowering the boom for each bucket load. Make sure the driver leaves the truck cab before you load the truck. Work over the back or side of the truck if at all possible.

To dump the load, push the clam lever forward. If possible, it's best to fill the clamshell at the back of the carrier and dump it at the side. This way you avoid swinging the clamshell over the cab of the carrier.

You just read about one loading, swinging, and dumping cycle. In actual practice, the operation of the clamshell is to repeat the cycle over and over until a given job is complete. Of course, there will be some minor variations and some unusual job situations. Use your good judgment to fit each unusual situation as it comes up.

Its common practice to return a crane equipped with a clamshell or dragline bucket to the parking area each night. Before relocating the crane to the parking area, you must position the boom, and secure the bucket by doing the following:

1. Ensuring the boom sections are fully retracted.
2. Swinging the boom to over-the-front and lower the boom to just above horizontal (TRAVEL position).
3. Inserting the turntable lock pin or engage the optional positive swing lock.
4. Ensuring the outriggers are fully retracted.
5. Hoisting the clamshell as close to the boom point as possible. (**NOTE:** The higher you get the bucket, the more clearance you'll have when passing high spots).
6. Closing the clamshell bucket.

The crane is now ready to travel. Drive carefully to the parking area. If you find the bucket sways too much on the way to the parking area, snub the bucket with a short piece of wire rope to the front of the crane. When you get the crane parked, lower the clamshell to the ground. When parked in this manner, there's no strain on the wire rope.

If you have to move the clamshell a long distance, take the bucket off the crane and haul it in a truck.

Open the bucket and set it in the bed of the truck. To disconnect the clamshell, reverse the procedures by disconnecting the hoses first.

216. General hydraulic crane maintenance tips and installing wire rope

Changing, removing, replacing attachments, and so forth, is considered part of crane operator's maintenance. Also, all wire ropes in use should be inspected daily. Worn, kinked, bird nested, fatigued, or otherwise damaged wire rope must be replaced immediately.

General hydraulic crane maintenance tips

Because of the complexities involved in crane maintenance, it's up to you, the operator, to locate and use the proper TO covering the types, sizes, and models of cranes used at your installation. Some general maintenance tips are as follows:

- Follow lubrication charts.
- Inspect the crane daily and comprehensively.
- Refuel the crane daily to prevent tank condensation.
- Remove grease with a clean cloth and a nonflammable solvent (if it is dropped on to walkways, catwalks, steps, the brake drums, or linings).
- Inspect the wire rope, sheaves, and rollers daily.
- Watch for kinks or flat spots in the wire rope and replace when necessary.
- Inspect the dielectric boom shield for breaks in the insulators.

Installing wire rope

When wire rope is properly installed, maintained, and lubricated, it will give many hours of satisfactory use. If misused, a new piece can be ruined immediately and must be replaced. Before installing new wire rope, make certain the wire rope to be used is the proper type and size. If you use the wrong type or size, the rope won't function properly, and it can even be dangerous. Also, make certain that if a wire rope is wound from the storage reel onto a drum, the reel is rotated in the same direction as the hoist. Correct and incorrect examples are shown on figure 2–30.

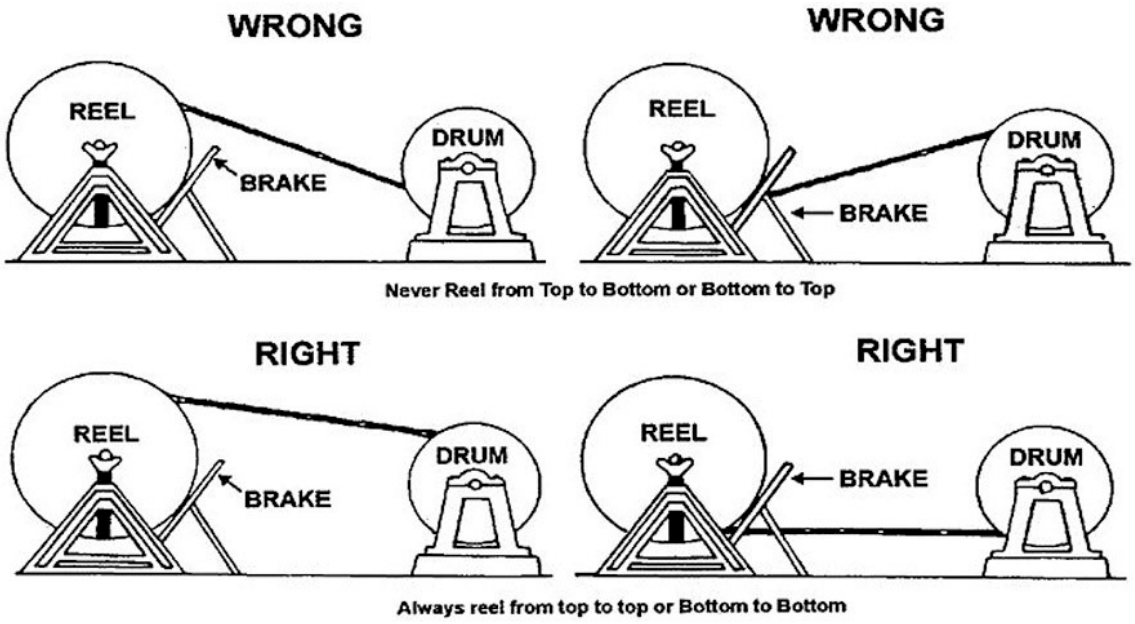


Figure 2–30. Installing new wire rope.

To install wire rope on a hoist drum (fig. 2–31), do the following:

1. Position the wire rope over the boom nose sheave and route it to the hoist drum.
2. Position the hoist drum with the wire rope anchor slot on top, as shown in figure.
3. Insert the wire rope through the slot and position it around the anchor wedge (fig. 2–31).
4. Position the anchor wedge in the drum slot; pull firmly on the free end of the wire rope to secure the wedge.
5. Slowly rotate the drum ensuring the first layer of wire rope is evenly wound onto the drum.
6. Install the remainder of the wire rope as applicable.

NOTE: The end of the wire rope should be even with the bottom of the anchor wedge. If the wedge doesn't fit securely in the slot, carefully tap the top of the wedge with a mallet.

Try to keep as much tension on the wire rope as you can when installing it onto the hoist drum. Tight winding on the drum is absolutely essential. As the drum rotates, make sure the adjacent turns are tight against one another. If need be, you may use a lead or brass hammer to tap the rope over against the preceding turns. Never use a steel hammer or a pry bar to move the wire rope over on the drum. These tools may easily damage the rope. After the wire rope is wound onto the hoist drum, reeve the wire rope as needed.

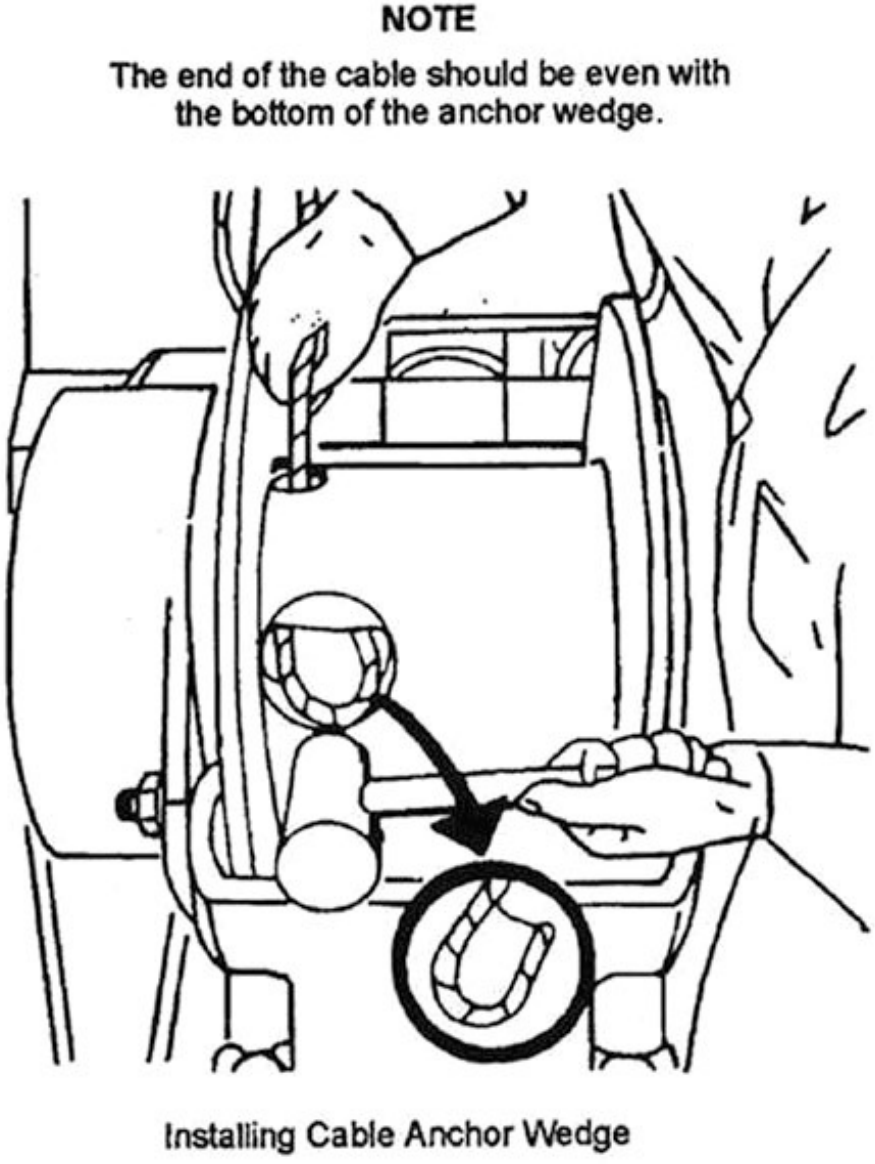


Figure 2–31. Installing wire rope.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

214. Crane overview

1. Why should a standard set of signals be used between helper and operator instead of signals made up between them?

2. What minimum distance should a crane or its load be allowed to work within power lines of 50kV?

3. What distance should be allowed for power lines over 50kV?

4. If your crane has a dielectric boom shield, where is it mounted?

5. What are the two main types of load charts on a crane?

6. What does the term *radius in feet* mean?

7. What is the top speed allowed when transporting a load with the crane (pick and carry)?

215. Operating a crane

1. What are the four types of inspection for a crane?

2. What type of inspection must be completed anytime the crane structure has been repaired?

3. Why is it so important to have the crane properly leveled when lifting a load?

4. What are some of the causes for most accidents involving hydraulic cranes?

5. During load estimation, what items must be included?

6. Why is it important that crane operators know how to perform load weight calculations?

7. What formula is used to calculate volume (V)?

8. Whose responsibility is it to determine the overall weight of the load?

9. How do you stop rotation of the hydraulic crane?

10. What two movements require accurate control in spotting a load?

11. How do you position a load if you have to move the crane?

12. When traveling within the job site, briefly state the three steps taken to prepare the crane for moving.

13. List the attachments needed for the clamshell conversion.

14. Where do you position the crane boom when attaching the clamshell?

216. General hydraulic crane maintenance tips and installing wire rope

1. What is the correct way to wind wire rope onto the crane drum?

2. Why should you *not* use a steel hammer or pry bar to move wire rope over the drum?

2–5. Rigging and Lifting

Rigging is a technique of handling materials using nylon rope, wire rope, chains, slings, and spreader bars. Although rigging is seldom a full-time job, you often use it while doing your regular job without even realizing you're doing it. Rigging applies whenever you hoist and move a load, whether it is with a crane, an excavator, or even a backhoe setting a piece of pipe in a trench. If careful attention to detail isn't paid, accidents can and will happen during these operations. By their nature, these are inherently complex and dangerous operations. You should make a conscious effort to study the material in this unit thoroughly and carefully. Its important information, and the knowledge you gain may well prevent serious, if not, fatal accidents.

There are various items used for rigging and lifting equipment. The term *rigging* typically involves the use of slings and spreader bars. Chains, ropes, and nylon are a few of components that can be used to make up slings. Whatever is used, it's important you use them properly and know certain facts about them.

217. Lifting equipment inspection and use

All rigging and lifting equipment must be visually inspected for obvious unsafe conditions before, during, and after each use. All slings will be inspected according to OSHA standards. A determination to remove rigging or lifting equipment from service requires experience and good judgment, especially when evaluating the remaining strength in a sling after allowing for normal wear. The safety of the sling depends primarily upon the remaining strength; however, removing a sling from service is preferable to downgrading its capacity (due to wear and tear) because typically, we as equipment operators do not have the technical knowledge or testing equipment to determine structurally how much to downgrade the sling. When in doubt, remove it from service because it is much better to err on the side of safety than have a serious accident because a sling failed.

The two types of inspection associated with rigging and lifting equipment are frequent and periodic. Take time and look at the definitions of the two types of inspections. *Frequent* is a visual inspection made before, during, and after each use of rigging equipment.

Periodic, a visual inspection performed on a recurring basis, is based on the type of use experienced by the equipment and may fall under several categories. They are as follows:

- Normal service.
- Severe service.
- Quarterly.
- Semiannually.
- Annual heavy service.

Chain design and uses

Chains are made of a series of links fastened (looped) through each other. Each link is made of an alloy steel rod bent into an oval shape and welded at one or two points. The weld ordinarily causes a slight bulge in the side or end of the link. The chain size refers to the diameter in inches of the rod used to make the links. Chain marked with a grade 8, 80, or 800 are the only grades allowed for lifting. Chains used for lifting will have a tag attached indicating the working load limit (WLL) and should be stored separately from all other chains. Chains used for tying down loads should never be used for lifting as they were not engineered for that task. Although chains may seem like relatively simple devices, there are many important factors about them you must know. We'll present four of these factors in this lesson. They are as follows:

- WLL.
- Using protective padding.

- Chain repair.
- Chain inspection.

Working load limit

The WLL is the maximum load an item is authorized to support when in general service and in compliance with specific parameters set by the manufacturer. The parameters could be as simple as angles of sling legs, CG measurements, and environmental conditions just to name a few. These limits are usually derived using a model that is in ideal conditions, and you should adjust (degrade) capacities if you are operating in anything other than ideal conditions.

Additionally, all devices used for lifting will have a tag from the manufacturer stating its WLL and any other applicable information (i.e., parameters). If a device does not have a tag, remove it from service immediately.

Chains will usually stretch under excessive loading. When this happens, the individual links will be bent slightly. Bent links are a warning that the chain has been overloaded and indicate it might fail suddenly when loaded. This sudden failure is unlike wire rope, which fails a strand at a time.

NOTE: If a chain is equipped with the proper hook, the hook should start to fail first indicating that the chain is overloaded.

Remember never to use a chain over its rated load limit. The safe WLLs for various chains will be different. Load charts are available from chain manufacturers to determine different safe working limits. Figures given on the charts assume that the load is applied in a straight pull rather than by an impact (shock loading). An impact load occurs when an object is dropped suddenly for a distance and stopped, or the slack is jerked out of a chain when starting a load. The impact load in either case is several times the weight of the load and should be avoided at all costs.

Using protective padding

When using chains as slings for hoisting heavy metal objects, you should insert padding (i.e., wooden dunnage, old pieces of carpet, heavy cardboard, etc.) around the sharp corners on the load to protect the chain links from being damaged. This will also protect the object you're lifting from damage.

Chain repair

You've heard the old cliché, "*A chain is no stronger than its weakest link*." No statement is truer than this one when dealing with chains. You should **never** wire or bolt a chain together. Instead, if a chain breaks, you should fasten it back together using a special repair or connecting links commonly called "cold shuts." They generally come assembled when purchased and are separated by driving a chisel or a screwdriver between the pieces. After the worn or damaged link has been removed, install the cold shut into the chain. When the cold shut is in place, you can use either a ball peen hammer or punch to close the cold shut. A good repair link can be stronger than a standard chain link; however, if the chain was used for lifting, remove it from service as a lifting chain. If you want to keep the chain for lifting duties, it must be sent to a competent person (one who has the authority to repair such devices) or back to the manufacturer for repairs. Once the repairs have been made, the chain must be load tested and retagged with the WLL. This process takes time and money and it may be cheaper to just purchase a new one.

Chain inspection

Chains should be inspected frequently, depending on the amount and type of use. Any defective links should be replaced. If several of the chain links are badly worn or stretched, the entire chain should be discarded. The following removal criteria should be strictly adhered to when inspecting chains:

- Missing or illegible sling identification (the tag).
- Cracks or breaks.
- Excessive wear, nicks, or gouges.

- Stretched links or components.
- Bent, twisted, or deformed links or components.
- Evidence of heat damage.
- Excessive pitting or corrosion.
- Lack of ability of chain or components to hinge (articulate) freely.
- Weld splatter.
- Other conditions, including visible damage, that cause doubt as to the continued use of the sling.
- Hooks are to be removed from service if they are cracked, have been opened more than 15 percent of the normal throat opening measured at the narrowest point, or twisted more than 10 degrees from the plane of the hook.

When you complete your qualification training package (QTP) for rigging and lifting, you will receive a complete list of requirements to inspect chains before use.

Construction features and uses of nylon and wire ropes

Basically a rope is a large stout cord made of strands of nylon or wire that have been twisted or braided together.

Nylon rope and slings

Nylon is a synthetic made from mineral products. The main qualities of nylon are its ability to stretch and to resume its normal length when the load is removed. Nylon rope is designated by its diameter up to five-eighths inches; then it's designated by a circumference up to 12 inches (12") or more. Nylon usually comes on a reel of 600–1,200 feet, depending on the size. The strength and useful life of nylon rope are shortened considerably by improper care. Do not uncoil new nylon rope by pulling the ends up through the eye of the coil. Unreel it as you would wire rope. Avoid coiling nylon in the same direction all the time, or you can unbalance the lay (the winding or braiding of the individual strands). When nylon rope is stretched more than 40 percent, it is likely to part. The stretch is immediately recovered with a snapback that sounds like a pistol shot.

Individual ropes and the manner in which they're used cause considerable variations in the minimum breaking strength. Nylon rope should be dry when stored, and it should always be stored in a dry place. It should be coiled on a spool or hung from pegs in a way that will allow the circulation of air. Avoid dragging the rope through sand and dirt or putting the rope over sharp edges. Always avoid exposure of nylon rope to excessive heat and chemicals. Finally, keep nylon rope out of direct exposure to sunlight. Ultraviolet (UV) rays in sunlight will deteriorate nylon and degrade its capacity significantly.

Nylon rope has a tensile strength that is nearly three times that of other types of fiber rope. The advantage of using nylon rope is that it is waterproof and has the ability to resume normal length after being stretched or absorbing shocks. It also resists abrasion, rot, decay, and fungus growth.

When nylon rope is properly handled and maintained, it should last more than five times longer than other types of fibrous line subjected to the same use. Nylon rope is also lighter, more flexible, less bulky, and easier to handle and store than manila line. When nylon is wet or frozen, it loses little strength.

Nylon rope can hold a load even when many strands are abraded. Normally when abrasion is local, the rope may be restored to use by cutting away the chafed section and splicing the ends. Chafing and stretching do not necessarily affect the load-carrying ability of nylon rope.

Nylon rope and sling inspection

Like chain-type slings or lifting equipment, nylon must be inspected frequently to ensure that it can be used for lifting operation. Below is a list of items to look for when inspecting. Remove the rope or sling from service if any of the following are present:

- Missing or illegible sling identification (the tag).
- Acid or caustic burns.
- Melting or charring of any part of the sling.
- Holes, tears, cuts, or snags in webbing.
- Broken or worn stitching in load bearing splices.
- Excessive abrasive wear.
- Knots in any part of the sling.
- Discoloration and brittle or stiff areas on any part of the sling, which may mean chemical or UV/sunlight damage.
- Fittings that are pitted, corroded, cracked, bent, twisted, gouged, or broken.
- Other conditions including visible damage that cause doubt as to the continued use of the sling.

As with the chain inspection before, this is only a small amount of items that you will look for when inspecting nylon type lifting equipment. When in doubt, have someone else look at, or remove it from service.

Wire rope

The number of strands, number of wires per strand, strand construction, and the type of lay classify wire rope. Wire and strand combination vary according to the purpose for which the rope is to be used. Figure 2–32, (views A through D) illustrates five examples of wire and strand combinations. The smaller and more numerous the wires, the more flexible the rope, but it's also less resistant to external abrasion. Rope made up of a smaller number of large wires is more resistant to external abrasion, but it's also less flexible. The 6 X 37 wire rope shown in view D on figure 2–32 is the most flexible of the six-strand wire ropes and is the standard rope in five-eighths inches size for the crane depicted in the load chart in the previous lesson. This permits its use with small sheaves and drums, such as on cranes. It's a very efficient rope because many inner strands are protected from abrasion by the outer strands. The stiffest and strongest type of rope for general use is the 6 X 19 rope shown in view B. This rope may be used over sheaves of large diameter if the speed is kept to moderate levels. It isn't suitable for rapid operation or for use over small sheaves because of its stiffness. A 6 X 7 wire rope is the least flexible of the standard rope constructions; however, it's well-suited to withstand abrasive wear because of the large outer wire.

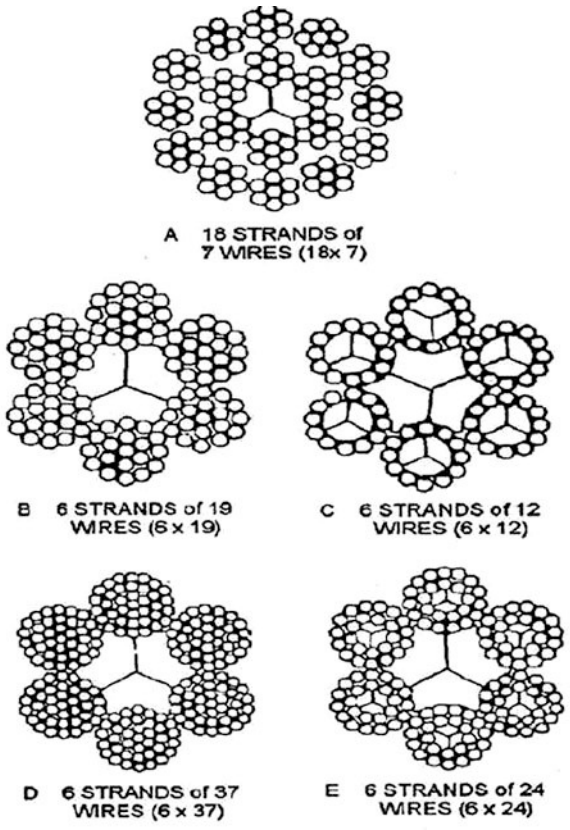


Figure 2–32. Wire strand construction.

Lay of a rope

The lay of a rope refers to the direction of the winding of the wires in the strands and the strands in the rope. Both may be wound in the same direction, or they may be wound in the opposite directions. Figure 2–33 illustrates some typical examples of rope lays. The following are three types of lays:

- Right regular and left regular.
- Right lang and left lang.
- Reverse.

Regular lay

Regular lays are the most common lay in wire rope. Left regular lay is used where the untwisting rotation of the rope will counteract the unscrewing forces in the supported load. An example of this would be when you remove drill rods and tubes used in deep well drilling. A counterclockwise motion is required; therefore, left regular lay wire rope is used.

Lang lay

Lang lays assure longer abrasion resistance of wires, less radical pressure on small diameter sheaves or drums by the ropes, and less binding stresses in wire than in regular lay wire rope. The disadvantages of the Lang lay are its tendencies to kink and unlaying or opening of the strands. These make it undesirable for use where grit, dust, and moisture are present. The standard direction of Lang lay is right, although it also comes in left lay.

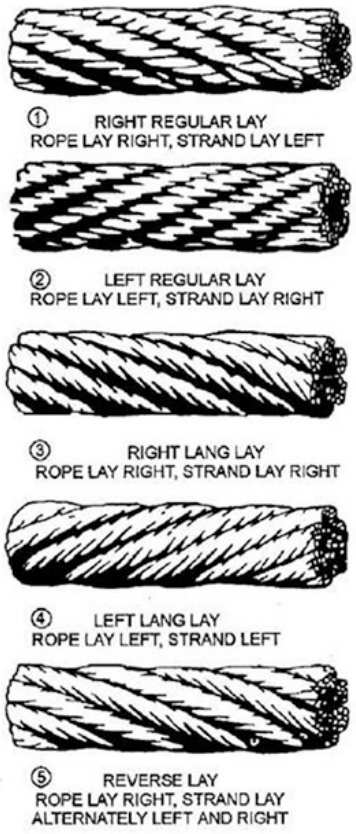


Figure 2–33. Typical wire rope lays.

Reverse lay

Reverse lays apply to rope in which the stands are alternately regular lay and Lang lay. The use of reverse lay rope is usually limited to certain types of conveyers. The strands' direction of lay is right, as it is for both regular lay and Lang lay ropes.

As stated earlier, the size of wire rope is designated by its diameter in inches. To determine the size of a wire rope, measure its greatest diameter (fig. 2–34). The weight of wire rope varies with the size and type of construction. No rule of thumb can be given for determining the weight.

Strength of wire rope

The strength of wire rope is determined by its size, grade, and method of fabrication. The individual wires may be made of various metals including traction steel, mild plow steel, plow steel, improved plow steel, or others. The identification of the size, type, and WLLs will be clearly stated on the reel the rope comes on. Always replace wire rope with the original size and type if possible. When replacing wire rope on a crane, check the manufacturer's recommendations.

You should always take care when rigging wire rope. At the time of fabrication, a lubricant is applied to wire rope. This lubricant generally doesn't last throughout the life of the rope. Use a good grade of oil or grease for lubricating, the grease should be free of acids and alkalis, and it should be light enough to penetrate the wires and strands of the rope.

Before you store wire rope, always clean and lubricate it. Then coil it on a spool and tag it according to its size and length. Store it in a dry place to reduce corrosion. Be sure to keep the wire rope away from chemicals and fumes that might attack the metal.

When loose wire rope is handled, small loops frequently form in the slack portions of the rope (fig. 2–35, A). If tension is applied to the rope while these loops are present, it will cause sharp kinks (fig. 2–35, B). After kinks have been formed in a wire rope, it's impossible to remove them; and the strength of the rope is seriously damaged at the point where the kinks occur (fig. 2–35, C). When using the rope for lifting, remove it from service if kinks occur.

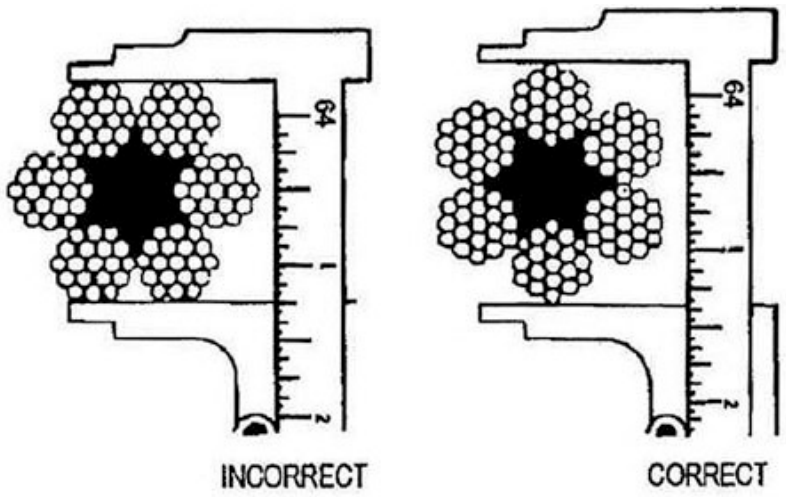


Figure 2–34. Measuring the diameter of wire rope.

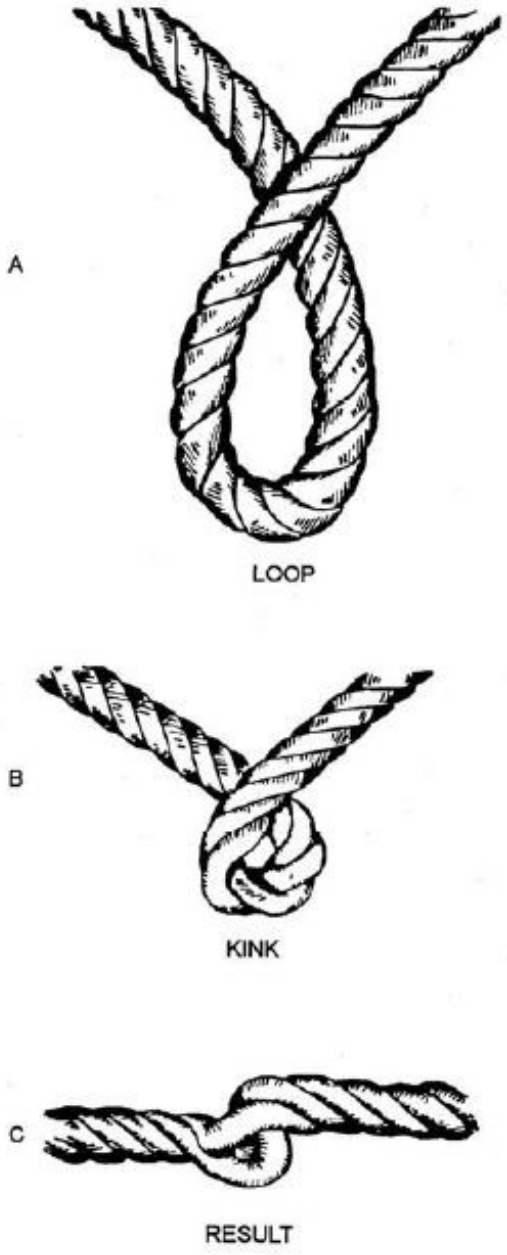


Figure 2–35. Loops and kinks in wire rope.

Wire rope may be cut with a wire rope cutter. In addition to the cutter, a hacksaw, bolt cutters, or a chop saw are acceptable methods for cutting wire rope. Never cut wire rope used for lifting with an oxyacetylene cutting torch. The heat created can degrade the wire.

Wire rope inspection

Before initial use of any wire rope or wire rope sling, it must be proof-tested not less than 100 percent or no more than 125 percent of rated capacity. Most of the time, this is completed by the manufacturer or by a person certified to do such testing. As a customer, you will be provided the certification documents to show compliance.

Now look at the following brief list of items to look for when inspecting:

- There are at least six randomly distributed broken wires in one rope lay or three broken wires in one strand in one lay.
- There is wear or scraping on one-third of the original diameter of outside individual wires.
- There is kinking, crushing, bird caging, or any other damage resulting in distortion of the wire rope structure.
- There is evidence of heat damage.
- This is only a small amount of items that you will look for when inspecting wire rope-type lifting equipment. Always refer back to the AFOSH standards covering MHE for more specific inspection criteria.

Attachments

Most of the attachments that are designed to be used with wire rope provide an eye on the end of the rope. In this way, maximum strength can be obtained when the rope is connected with another rope, a hook, or a ring. Figure 2–36, views A through E show a number of attachments used with the eye splice. Two of the most common attachments you will come across are hooks and shackles (fig. 2–36 D and E).

An end fitting may be placed directly on the wire rope. Some of the fittings that can be easily and quickly changed are open sockets, bridge sockets, wedge sockets, clips, and clamps, (fig. 2–37 views B through F). The basket socket end fittings include closed sockets, open sockets, and bridge sockets (fig. 2–37, views A through C).

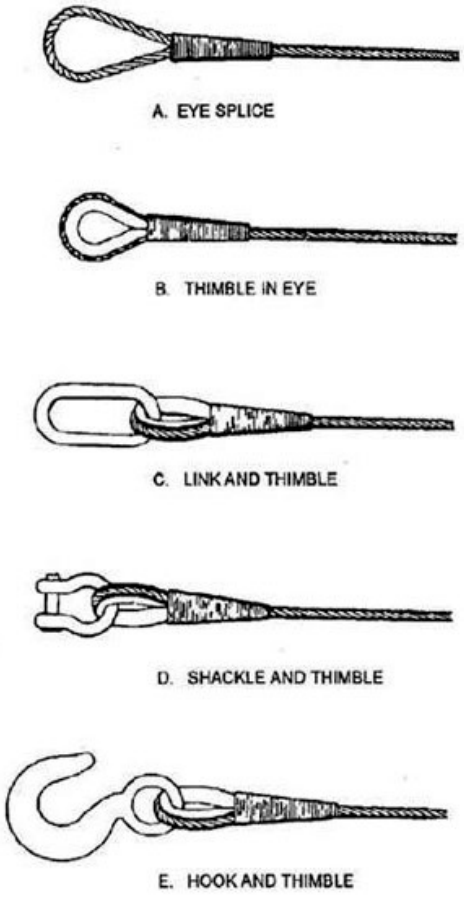


Figure 2–36. Attachments with eye splice.

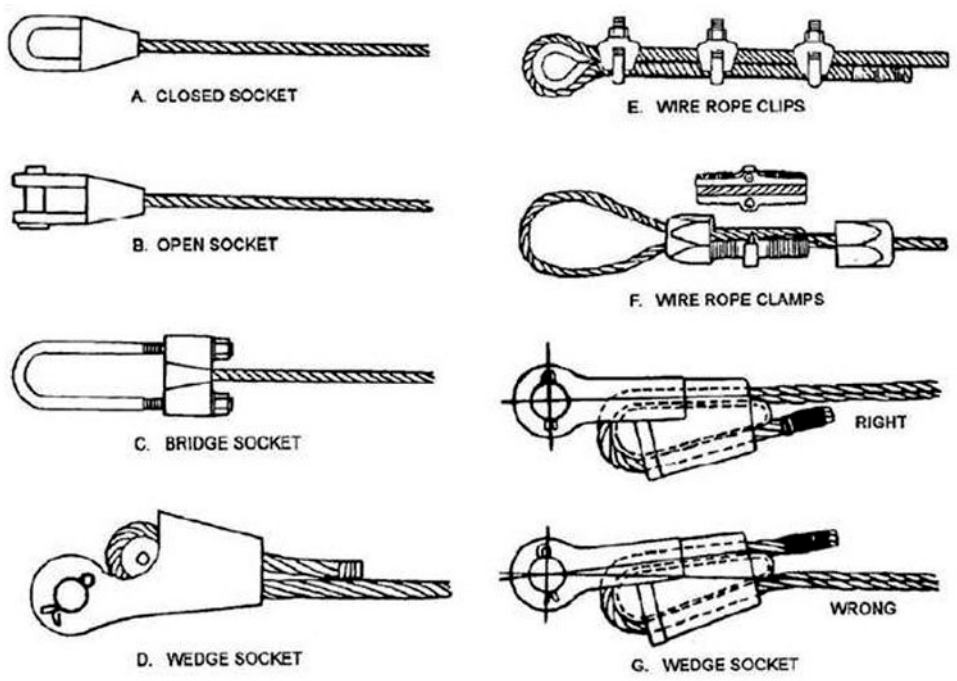


Figure 2–37. Basket socket with fittings.

Hooks

Hooks are likely the most widely used pieces of hardware associated with rigging and lifting. They are ideal for lifting loads without directly tying them to the object. Although there are many different types of hooks for different applications, all hooks will either be forged, stamped or cast with a manufacturer's ID, its rated capacity or WLL, and a latch if applicable. A thorough inspection of all hardware is necessary prior to use to ensure a safe lift for the equipment and also the rigger.

Hooks should be inspected by a competent person at the beginning of each workday and definitely before lifting a fully rated load. When inspecting hooks, they must be as follows:

- Be free from any cracks, nicks, or gouges.
- Not have a throat opening more than 5% of normal (or exceed ¼ inch of original).
- Not be twisted off center more than 10% from its longitudinal axis.
- Not to have excessive wear in the saddle of the hook.
- Ensure latches (if equipped) are in safe working order.

If any of these items are present at the time of inspection, the hook must be cut in half with a cutting torch and discarded. If you are unsure if the hook you are using is not strong enough to lift the load, using a shackle is the safest bet.

Shackles

Shackles, just like hooks are an essential part to rigging operations. There are two types of shackles you are likely to come across; the anchor and the chain shackle. Both are available with screw pins or rounds pins (held in place with a cotter pin). Shackles are only meant to be used in the same configuration as intended by the manufacturer, meaning, do not replace any of the pin types with a substitute such as a bolt. If the original pin is lost or does not fit properly anymore due to wear, the shackle must be removed from service. When you are finished using the shackle be sure to replace the pin before storing to prevent loss.

Similar to the nomenclature on a hook, a shackle will be stamped or embossed with its size (by measuring the diameter of the body) and its rated capacity or WLL. Also an inspection by a competent person prior to the beginning of the workday and a fully rated load is required. To complete a shackle inspection, look for the following:

- Any cracks, nicks, or gouges.
- Any bend, distortion, or excessive wear of the pin or body.
- Illegible nomenclature (capacity, manufacturer ID, and size).

218. Purpose and features of slings and spreader bars

All personnel involved in rigging and lifting need a thorough knowledge and understanding of the effects of the CG and the distribution of forces when lifting. The CG is the point on a load where all the weight is concentrated. To make level lifts, you should place the crane hook right above the CG. If the crane hook is too far to one side of the CG, dangerous tilting can take place and you should correct the situation immediately.

Slings

Slings can be manufactured from alloy steel chains, wire rope, and synthetic nylon rope. They're designed to aid in lifting a load and to help compensate for the CG. Slings are manufactured using exacting engineering standards and as such, you should never try and fabricate a sling. Home-made slings and slings that have been repaired by someone other than a certified professional should never be used. All slings will have an identification tag with all the information needed to use the sling safely.

To make a level lift, you should place the crane hook directly above the CG. If you use sling legs of the same length on a load where the weight is distributed unequally, the CG won't be in line with the hook. When you lift the load, it will tilt. To compensate for this, use sling legs of unequal length, and put the CG under the hook for a balanced load.

Characteristics

There are numerous materials that can be used to make slings and each has advantages. Some examples are as follows:

- Slings made of nylon rope make good sling material because of their flexibility; however, they're more easily damaged by sharp edges and have a relatively low capacity.
- Wire ropes are widely used for slings because they have a combination of flexibility and strength.
- Chain slings are used especially where sharp edges of metal would cut wire rope or where very hot items are lifted as in foundries or blacksmith shops.
- Nylon rope slings are used for lifting comparatively light loads and for temporary jobs.
- Properly designed and appropriately fabricated wire rope slings are the safest type of slings. They don't wear away as do nylon rope slings, nor are they susceptible to the "weakest link" condition as slings made of chains.

Types

There are many types of slings, but we will discuss three—endless slings, single-leg slings, and bridle slings.

Endless slings

An endless sling is easy to handle and can be used as a choker hitch (fig. 2–38). Many manufacturers offer endless slings (or round slings) in many sizes and configurations to meet the needs of just about any situation.

Single-leg slings

Single-leg slings are commonly referred to as a strap. The single-leg sling can be used as a choker hitch (fig. 2–39, view A) in hoisting by passing one eye through the other and over the hoisting hook. The single-leg sling is also useful as a double-anchor hitch (fig. 2–39, view B). The double-anchor hitch works well for hoisting drums or other cylindrical objects where a sling must tighten itself under strain and lift by friction against the sides of the object.

Bridle slings

Single-leg slings can be used to make various types of bridles. The most common type of bridle slings are the 4-legged bridles shown in fig. 2–40. Either two or more slings may be used for a given combination.

The double choker hitch (fig. 2–40) provides excellent load stability when the load is distributed equally among each sling leg. The load hook is directly over the CG of the load, and the load is raised level. The use of bridle slings requires the sling angles be carefully determined to ensure the individual legs aren't overloaded.

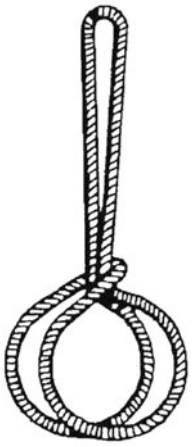


Figure 2–38. Endless sling rigged as a choker hitch.

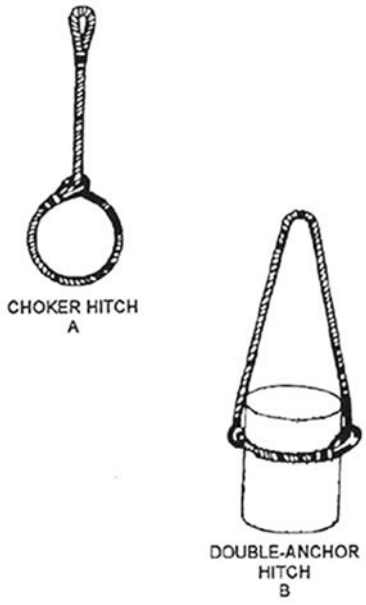


Figure 2–39. Single-leg slings.

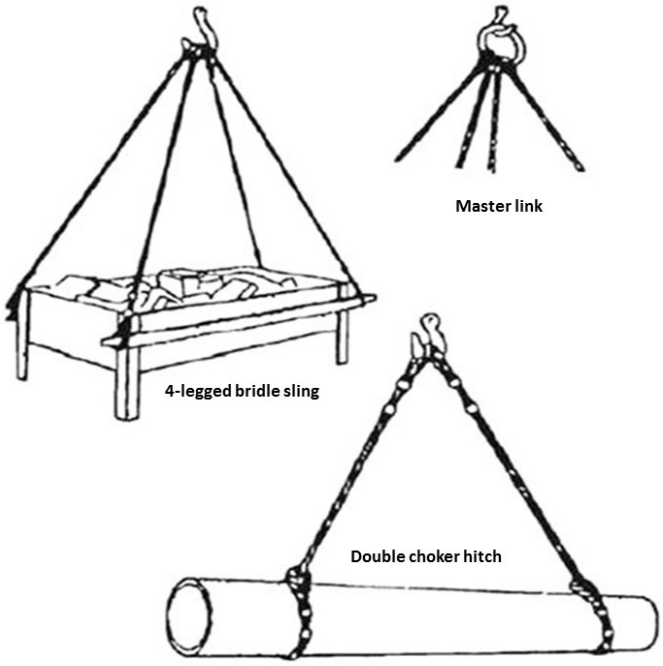


Figure 2–40. Mulitilegged bridle slings.

You should never conclude that a three- or four-leg bridle sling could safely lift a load equal to the safe load on one leg multiplied by the number of legs. This is because there's no way to know if each leg is carrying its share of the load. With a four-legged bridle sling lifting a rigid load, it's possible that only two legs actually support the full load while the other two only balance it. Therefore, you should calculate the weight capacity for at least two legs of the sling to be capable of handling the entire weight of the load. Many pieces of equipment have eyes fastened to them to aid in lifting. With some loads, fastening a hook to the eye of each sling leg is enough to secure the sling to the load.

When nylon line or wire rope slings will be exposed to sharp edges, use a protective pad at the corners of the load. Pieces of wood or old rubber tires can also be used for padding.

219. Calculating sling requirements

It is important to understand why the sling angle needs to be calculated. When considering Figure 2–41, it is apparent that 2 slings are connected to an object that weighs 10,000 lbs. What is not apparent, is how much each sling is required to bear while lifting this weight. Some look at this setup and guess that each sling would only be required to bear 5,000 lbs. because of the number of slings being attached towards each end of the object. However, this is only the case if the slings are at a 90 degree angle, or perfectly perpendicular to the object. In this figure, we see that the slings are attached at close to 45 degree angles. A calculation needs to be made to determine exactly how much each sling will be required to bear to safely rig this object for lifting. This calculation is called the sling angle factor.

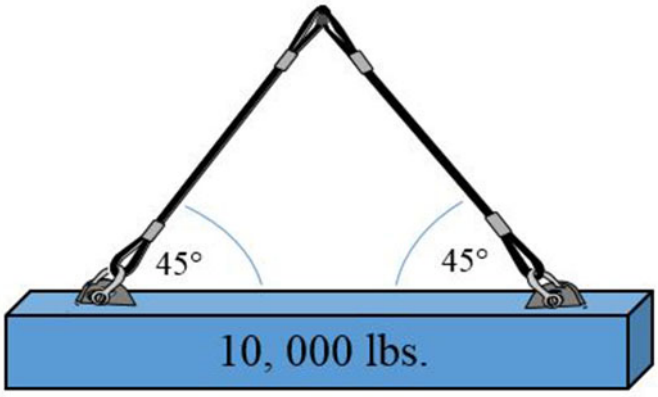


Figure 2–41. Sling angle requirements.

Sling angle

When you're using slings, remember that the greater the angle from vertical, the greater the stress on the sling legs (fig. 2–42).

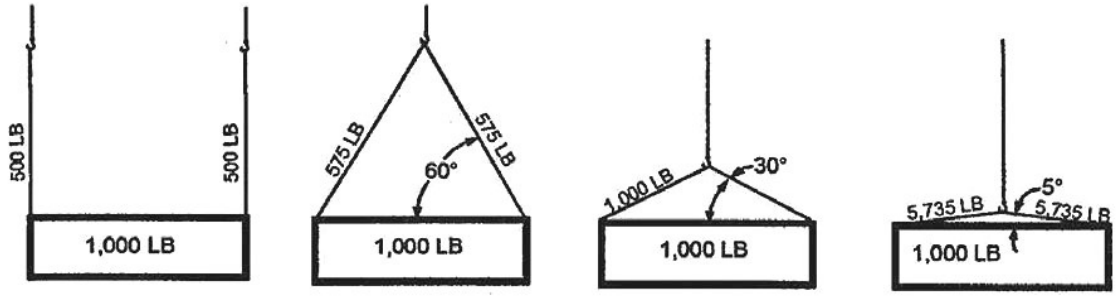


Figure 2–42. Stress on slings at various vertical angles.

The rated capacity of any sling depends on the size, the configuration, and the angles formed by the legs of the sling and the horizontal. A sling with two legs used to lift a 1,000-pound object will have 500 lbs. of the load on each leg when the sling legs are at 90 degrees. The load stress on each leg increases as the angle decreases. For example, if the sling angle is 30 degrees when lifting the same 1,000 lbs. object, the load is 1,000 lbs. on each leg. For this reason, you should try to keep all sling angles greater than 45 degrees.

WARNING: Sling angles approaching 30 degrees are considered extremely hazardous and must be avoided.

Sling angle factor

When calculating for the sling angle factor, it's important to note that sling angles affect more than just the sling requirements.

The sling angle affects the crane hook. Looking at most hooks you might notice 2 sling indicator lines embossed on it. If the sling angle exceeds the points marked by these indicators, it can result in excessive stress on the hook causing it to twist or spread.

The sling angle also affects the object being lifted. For instance, if the connection points are at the extremity of the object, it is important to pay attention to the sling angle. If the sling angle is too low, the sling can come together and crush the object. To avoid this, operators use such things as spreader bars. There are also times connections can be made at the bottom of the object which also eliminates this problem.

This angle can also impact the selection of rigging gear. The rigging gear under consideration is everything being used to lift an object. In figure 2–42, this gear would include both slings and the two shackles connecting the slings to the object. Use the sling angle factor to determine the required capacity of the rigging gear.

Calculating sling angle factor

Using the image from figure 2–41 with the 45 degree sling angles, half of the weight of the object would be multiplied by the corresponding multiplier. In this case, 5,000 lbs. will be multiplied by 1.414. 1.414 is the sling angle factor used (with 45° sling angle) to determine the weight to be lifted by the rigging. The following formula should help clarify this process (fig. 2–43).

45 degree multiplier from the load factor chart = 1.414

Half of the weight of the object to be lifted = 5,000 lbs.

Required capacity of the rigging = 1.414 x 5,000

= **7,070 lbs.**

Sling Angle Factor	
Angle	Multiplier
90	1.000
75	1.035
60	1.154
55	1.220
45	1.414
30	2.000

Figure 2–43. Load factor chart.

Spreader bars

The primary purpose of spreader bars is to hold two or more linear lines attached to the object to be lifted apart (fig. 2–44). This allows for a better CG and load distribution. The bars are also used to prevent crushing and damaging the load. Spreader bars are short bars or pipes with eyes fastened to each end. By setting spreader bars in the sling legs above the top of the load, you can change the angle of the sling leg and avoid crushing the load particularly in the upper portion.

Spreader bars are also used in lifting long or oversized objects to control the sling angle (fig. 2–45). When you're using spreader bars, make sure you don't overload the end connection. A spreader bar should have a rated capacity that's the same as hooks and shackles. A good rule of thumb is the thickness of the spreaders end connection should be the same as the thickness of the shackle pin. Use equipment rated at the same capacities when grouping them together.

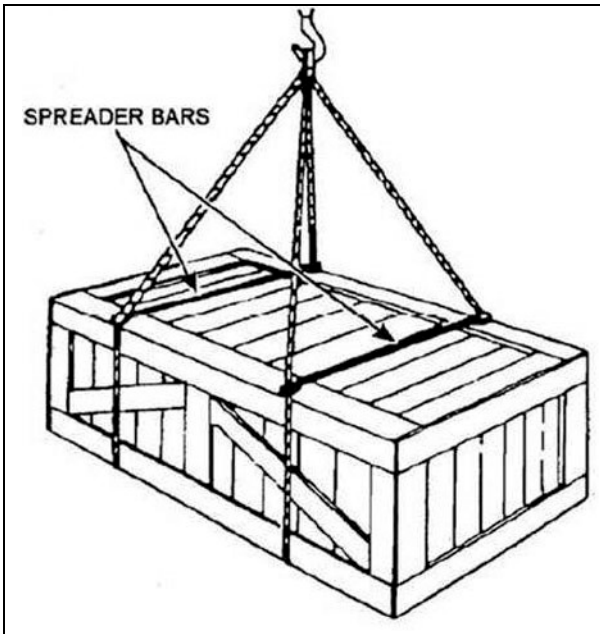


Figure 2–44. Using spreader bars.

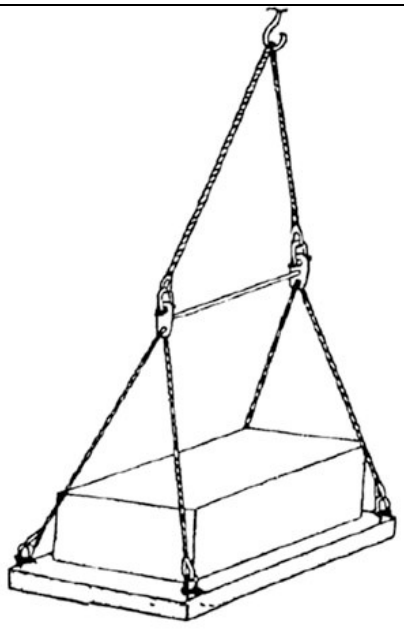


Figure 2–45. Spreader bar used with an oversized load.

Center of Gravity

Stability of the load is important in the rigging process. A stable load is a load in which the CG of the load is directly below the hook (fig. 2–46). When a load is suspended, it will always shift to the position

below the hook, which may cause the load to swing when lifted and may also cause uneven stress on the rigging. To rig a stable load, establish the CG. Once you've done this, simply swing the hook over the CG, and select the length of sling needed from the hook to the lifting point of the load.

Here are two important points about lifting with multi-legged slings: When using a multi-legged bridle sling, don't assume a three- or four-leg hitch will safely lift a load equal to the safe load on one leg multiplied by the number of legs.

As figure 2–47 shows, with a four-legged bridle sling lifting a rigid load, it's possible for two of the legs to support practically the whole load while the other two only balance it.

NOTE: If all the legs of a multi-legged sling aren't required, secure the remaining legs out of the way.

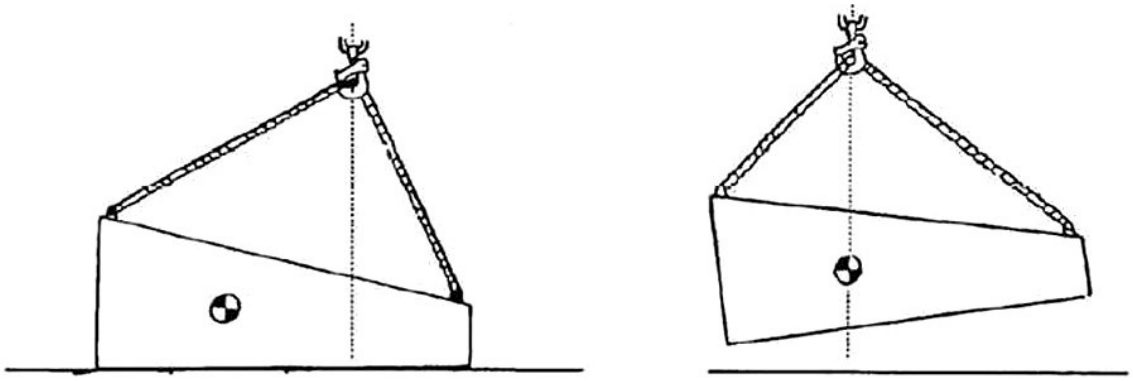


Figure 2–46. Load shifting when lifted.

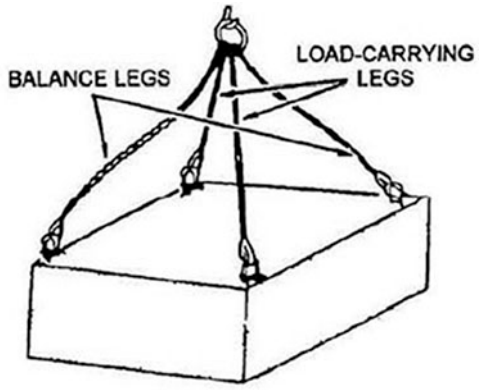


Figure 2–47. Multi-legged bridle sling lifting a load.

Determine center of gravity

To determine the CG of a symmetrical object, it must be divided equally among all three of the object's axis. To help understand this concept, consider a rectangular object (fig. 2–48, view A). The dimensions of this object are as follows:

Length = 12 feet

Width = 5 feet

Height = 3 feet

With these dimensions in mind, each of these measurements will be divided equally. These calculations will determine the center point of each of these dimensions. Additionally, because this is a symmetrical object, these center points will intersect giving us the exact CG of the object as shown in figure 2–48, view B.

Calculate the center point of each dimension by dividing each measurement in half:

Length = 12 feet
Center point = 12 ÷ 2 = 6 feet

Width = 5 feet
Center point = 5 ÷ 2 = 2.5 feet

Height = 3 feet
Center point = 3 ÷ 2 = 1.5 feet

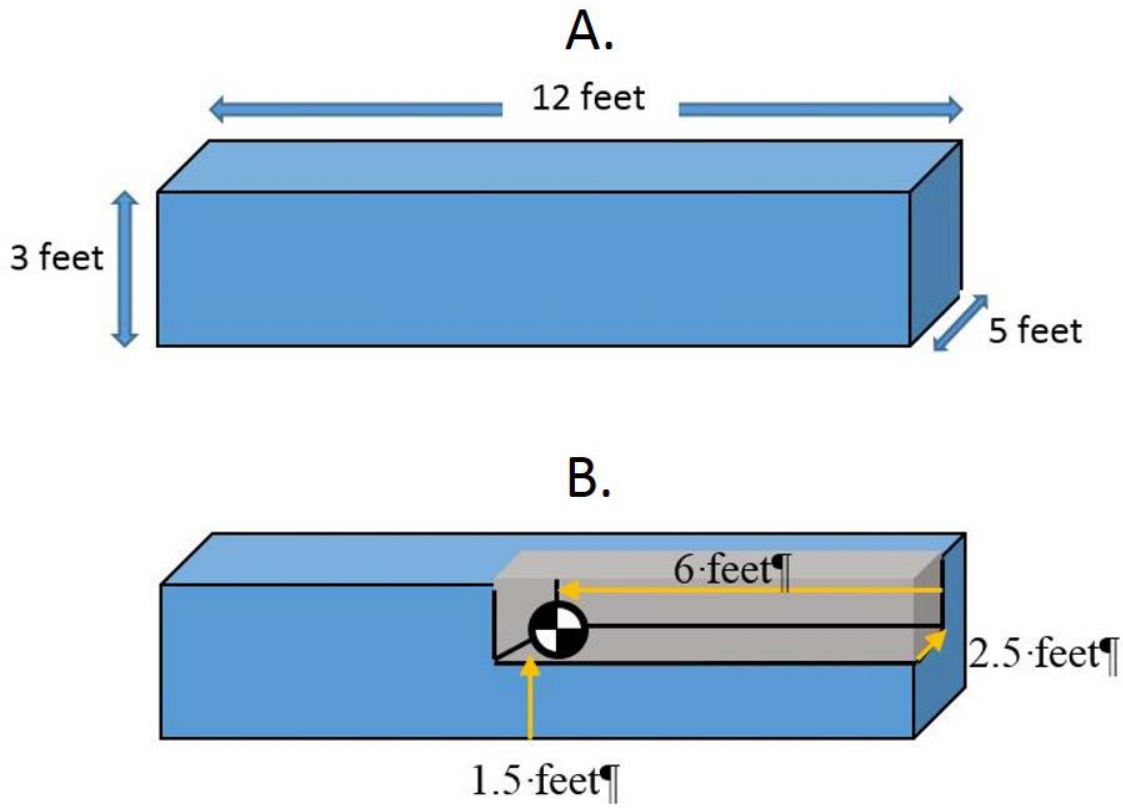


Figure 2–48. Determining center of gravity, views A and B.

NOTE: The scenario covered will almost never be this simple. This scenario solely determined the CG of a symmetrical object. A symmetrical object is equal on all sides. These objects have equal weight around an axis. They will also be made of the same material throughout. Just know that many instances will occur in real world operations where operators will be working with objects which are not symmetrical. Additional training will be needed before attempting to determine the CG of these objects.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

217. Lifting equipment inspection and use

1. What are the two types of inspections on chain, nylon rope, and wire rope?

2. How are chains constructed?

3. When chains are stretched under excessive loads, what part of the chain should be the weakest part?

4. What is a cold shut used for?

5. How does the AF designate nylon rope?

6. How is wire rope classified?

7. How is the strength of wire rope determined?

8. What should you do before storing wire rope?

9. What must be done if any discrepancies are found during a hook inspection, and who can perform these inspections?

10. How will you know what shackles rated capacity or WLL is?

218. Purpose and features of slings and spreader bars

1. Where is the center of gravity on a load?

2. What will happen if you use the same length sling legs on a load where the weight is distributed unequally?

3. When do you use slings made of chains?

4. Why should you carefully determine the sling angle when using a bridle sling?

219. Calculating sling requirements

1. What does the rated capacity of any sling depend upon?

2. What sling angle multiplier is used when your sling angles are 60°?

3. What are three purposes of using a spreader bar?

4. What can happen if the CG is not directly below the hook when lifted?

Answers to Self-Test Questions

207

1. To ensure the vehicle is safe to drive.
2. So that every individual inspects the same items, the same way, every time.
3. By opening the engine compartment.
4. A drop of two psi for the tractor alone or a drop of three psi for a combination.
5. At approximately 40 psi.

208

1. Join the tractor and the semitrailer together.
2. To support the front of the trailer when it is not attached to the tractor.
3. By pulling on the handle until it locks in the OPEN position.
4. To keep the weight of the trailer from dropping suddenly on the landing gear if it isn't in full contact with the ground.
5. Always use a board or some other type of material under the landing gear to prevent sinking.

209

1. Keep the unit close enough to the road edge to keep a following vehicle from making an attempt to pass on the right.
2. Left.
3. Back to the left. Because you can see where you're backing.
4. Premature mechanical damage to the drive train and to the coupling.
5. Use the foot (service) brakes alone, since they control both the tractor-trailer simultaneously.
6. Trailer handbrake.
7. Skidding or locked wheels, normally due to hard braking in emergency or hazardous conditions.
8. 450 feet.
9. Help slow the vehicle reducing the need for using the brakes.
10. Frequently drain the air tanks.

210

1. Improper placement of a concentrated load.
2. The heavier cargo should be placed on the bottom. This prevents a top heavy load and it also prevents possible damage to the lighter cargo from the weight of the heavier cargo.

3. Block and pyramid them if laying them on their sides or block or tie upright barrels to prevent shifting or overturning.
4. During daylight, place a red flag or a red light at night at the extreme end of the longest article projecting from the vehicle.
5. (1) Type of material or equipment.
   (2) The speed.
   (3) The distance of travel.

211

1. To tighten chains for securing loads in place.
2. Fasten the safety hooks or use safety wire to keep the binder closed.
3. (1) Speed.
   (2) Wear on equipment.
   (3) Protection of roads and improved areas.
4. Tires or thick, wide boards.
5. Back the trailer into a shallow, dry ditch or push a pile of dirt up behind the trailer.
6. Firmly against the trailer in the FLOAT position.
7. 4 chains.
8. Display a sign on the front of the tractor and the back of the trailer that reads “DANGER—WIDE LOAD” or “OVERSIZE LOAD.” Tie red flags on the outer most part of the blade and whenever possible, get escort help from the security police.

212

1. Only the operator.
2. All terrain AT or rough terrain RT forklifts F/L.
3. 10,000 lbs & 10 ½ feet.
4. The boom shooter F/L has the potential to tip when fully raised.

213

1. Use a spotter.
2. Decrease your speed and begin elevating the load so it is slightly above the trailer.

214

1. In case there’s another helper assigned to work with the operator.
2. 10 feet.
3. 10 feet plus 0.4-inches for every one kV over 50.
4. To the boom tip section.
5. (1) On outrigger.
   (2) On rubber.
6. Horizontal distance from the axis of rotation to the tip of the boom.
7. Two and one-half mph.

215

1. (1) Initial.
   (2) Periodic.
   (3) Frequent (preuse).
   (4) Preop (daily).
2. Initial.
3. If the crane is only slightly out-of-level, it can tip over.
4. (1) Crane out of level.

(2) Bad surface conditions.

(3) Outriggers used improperly or not used at all.

(4). Improper crane operation.

5. The weight of the item(s) to be lifted and all gear being used to rig the crane to the load.
6. So operators will know size and capacity of the rigging, lifting capacity of the crane and size/type of vehicle needed to transport the load.
7. Volume (V) = Area (A) x Height (H); or simply V = A x H
8. Operator calculates the overall weight.
9. Return the control lever to the NEUTRAL position.
10. (1) Hoist movements.

    (2) Swing movements.
11. Lower the load to the ground, then reposition the crane.
12. (1) Fully retract boom sections.

    (2) Swing and lower boom over-the-front.

    (3) Insert the turntable lock pin.
13. (1) Bucket.

    (2) Combination hose.

    (3) Tagline reel mounted on the boom.

    (4) A separate fairlead assembly.
14. In a HORIZONTAL position with the boom tip over the clamshell.

216

1. With the reel rotating in the same direction as the hoist.
2. These tools may easily damage the rope.

217

1. (1) Frequent.

    (2) Periodic.
2. By series of links fastened through each other.
3. The hook.
4. To fasten together a broken chain.
5. By inches of diameter and circumferences.
6. (1) Number of strands.

    (2) Number of wires per strand.

    (3) Strand construction.

    (4) Type of lay.
7. By its size, grade, and method of fabrication.
8. Clean and lubricate, then coil it on a spool and tag it according to its size and length.
9. Hook must be cut in half with a cutting torch and discarded.
10. It will be stamped or embossed with its size (by measuring the diameter of the body).

218

1. Where all the weight is concentrated.
2. The load will tilt when you lift it.
3. Where sharp edges of metal are and when lifting hot items.
4. To ensure the individual legs are not overloaded.

219

1. (1) The size.
   (2) The configuration.
   (3) The angles formed by the legs of the sling and the horizontal.
2. Multiplier of 1.154.
3. (1) Holds two or more linear lines apart when lifted.
   (2) Prevents crushing or damaging the load.
   (3) Helps control sling angles when lifting long or oversized loads.
4. The load can swing and can cause uneven stress on the rigging.

Complete the unit review exercises before going to the next unit.

Unit Review Exercises

Note to Student: Consider all choices carefully, select the *best* answer to each question, and *circle* the corresponding letter. When you have completed all unit review exercises, transfer your answers to the Field-Scoring Answer Sheet.

Do not return your answer sheet to the Air Force Career Development Academy (AFCDA).

44. (207) You begin a tractor trailer pretrip inspection by
    a. moving down the side of the vehicle.
    b. opening the engine compartment.
    c. checking the fifth wheel.
    d. doing a light check.

45. (207) When conducting a leak down test during the air system check, a drop of how many pounds per square inch (psi) for a tractor trailer could mean a leak in the system?
    a. Two.
    b. Three.
    c. Four.
    d. Five.

46. (208) Which sequence of components is the *correct* order for connecting a tractor to a semitrailer?
    a. Electric cable, brake lines, and fifth wheel.
    b. Fifth wheel, brake lines, and electric cable.
    c. Electric cable, fifth wheel, and brake lines.
    d. Brake lines, fifth wheel, and electric cable.

47. (208) What steps do you take to properly disconnect a tractor from a breakaway trailer?
    a. Open fifth wheel handle, disconnect airbrake lines and electric cable, and raise hydraulic ram.
    b. Raise hydraulic ram, open fifth wheel handle, and disconnect airbrake lines and electric cable.
    c. Open fifth wheel handle, disconnect airbrake lines and electric cable, and lower hydraulic ram.
    d. Lower hydraulic ram, disconnect airbrake lines and electric cable, and open fifth-wheel handle.

48. (209) When you are making a turn with a tractor trailer, you must keep in mind the trailer has a tendency to
    a. cut the corner.
    b. slow the tractor.
    c. continue going straight.
    d. swing wide on the corner.

49. (209) What condition has occurred where the tractor and trailer become jammed together at an acute angle?
    a. Pigtail.
    b. Bobtail.
    c. Jackknife.
    d. Piggyback.

50. (209) What position is *best* for unloading a tractor trailer at a warehouse dock?
    a. Park parallel to the dock.
    b. Pull forward into the dock.
    c. Back toward the left and turn toward the dock.
    d. Back toward the right and turn toward the dock.

51. (209) What immediate action should be taken to regain control of a tractor trailer in a skid?
    a. Apply only the trailer brakes.
    b. Apply only the tractor brakes.
    c. Release the brakes to get the wheels turning.
    d. Keep the brakes depressed to stop the tractor trailer.

52. (210) Before you begin loading a vehicle, you *must* first determine the vehicles
    a. turning radius.
    b. weight capacity.
    c. height limitations.
    d. tire characteristics.

53. (210) What factor(s) determines the method of securing cargo?
    a. Type of cargo only.
    b. Distance to be traveled only.
    c. Type of vehicle transporting the cargo.
    d. Type of cargo, speed of the vehicle, and distance to be traveled.

54. (211) Normally, if there is no loading ramp available to load a dozer, you should
    a. back the dozer onto the trailer.
    b. push up a pile of dirt behind the trailer.
    c. use a hydraulic crane to load the dozer on a trailer.
    d. find a street with a curb and back the trailer up to the curb.

55. (211) If a spring binder is *not* used, what can happen to a chain used for tying down a rubber tired loader?
    a. The chain may squeak.
    b. The chain could loosen.
    c. The chain will remain tight through the trip.
    d. You never use spring binders for rubber tire equipment.

56. (212) Where on a forklift is the load capacity displayed?
    a. Windshield.
    b. Data plate.
    c. Dashboard.
    d. Under the seat.

57. (213) When moving pallets with a forklift, you should make sure the forks are spaced far enough apart to
    a. ensure load stability.
    b. maximize the lifting capacity.
    c. decrease the weight of the load.
    d. increase your visibility of the forks.

58. (213) When operating a forklift, what do you do after you have the forks under the pallet?
    a. Accelerate quickly and pull back on the tilt-control lever.
    b. Accelerate slightly and pull back on the lift-control lever.
    c. Accelerate quickly and push forward on the lift-control lever.
    d. Accelerate slightly and push forward on the tilt-control lever.

59. (214) What number of feet is the *minimum* clearance required between power lines and any part of a hydraulic crane or its load?
    a. Two.
    b. Four.
    c. Eight.
    d. Ten.

60. (214) Making a lift with a crane without the use of outriggers is known as what type of lift?
    a. On rubber.
    b. Stability.
    c. Control.
    d. Free.

61. (215) While operating a crane, what must you do if you lose sight of the load or signal person?
    a. Stop the operation immediately.
    b. Lower the load and wait for further instructions.
    c. Raise the load until you find the signalman again.
    d. Maneuver the crane until you see the load and signalman again.

62. (215) When moving the hydraulic crane within the job site, you swing the boom to the front and
    a. release boom hoist brake.
    b. insert the turntable lock pin.
    c. disengage the swing lock lever.
    d. keep the load high enough to clear the ground in a 360 degrees arc.

63. (215) After assembling the clamshell for use on a hydraulic crane, what should carry the entire load between the clamshell and the reel?
    a. Hoist line.
    b. Dragline.
    c. Tagline.
    d. Jibline

64. (216) What would you use to clean grease from the brake drums and brake linings of a crane?
    a. A clean dry rag.
    b. Gasoline and a clean cloth.
    c. Alcohol-based solvent and steel wool.
    d. Nonflammable solvent and a clean cloth.

65. (216) When winding wire rope onto the hydraulic crane hoist drum, which hammer should *not* be used to tap the rope?
    a. Lead.
    b. Brass.
    c. Steel.
    d. Fiberglass.

66. (217) Who establishes the maximum allowable load limit for pieces of lifting equipment?
    a. Manufacturer.
    b. Superintendent.
    c. Unit’s safety officer.
    d. End user of the equipment.

67. (217) What component will normally fail *first* to indicate that a chain has been overloaded?
    a. Hook.
    b. Chain link.
    c. Link strand.
    d. Cold shut link.

68. (217) Which factor has the greatest effect in shortening the useful life of nylon rope?
    a. Dry storage.
    b. Improper care.
    c. Exposure to air.
    d. Improper coiling.

69. (218) What are chain slings *especially* used for when lifting?
    a. Handling very hot items.
    b. Comparatively light loads.
    c. Items big and bulky in nature.
    d. Items with no sharp edges or points.

70. (218) What three types of slings that can be used to lift loads?
    a. Endless, single-leg, and bridle.
    b. Endless, single-leg, and double.
    c. Combination, bridle, and endless.
    d. Single-leg, combination, and double.

71. (219) The primary purpose of a spreader bar is to hold two linear lines apart and to
    a. Allow for a better center of gravity and load distribution.
    b. Allow operator to determine center of gravity.
    c. Prevent shifting of the center of gravity.
    d. Prevent overloading sling legs.

Please read the unit menu for unit 3 and continue ➔

Unit 3. Excavation and Shoring

THE CONSTRUCTION AND MAINTENANCE of base facilities, buildings, and utility systems almost always require removing large amounts of soil, or *excavation*. New construction requires the excavation of foundation ditches and trenches or the removal of soil in precise areas. Excavation equipment are specifically designed for these tasks. After digging trenches and ditches, Airmen may have to work in those holes—which can be extremely dangerous if the walls of the ditch crumble. Wall support structures called shoring create a safe work area. This unit discusses equipment for digging ditches and trenches, as well as excavation safety.

3–1. Excavation Equipment

There are three primary types of excavation—long, narrow ditches, small digging projects and large digging projects. The three categories of equipment for these tasks are trenching machines, backhoes and mini excavators, and excavators.

Before starting any excavation work, you must have an approved Air Force (AF) Form 103, Base Civil Engineering Work Clearance Request. This form lets the other shops and utility companies verify there are no buried utility lines in the area.

220. Trenching machines

Trenching machines can dig a trench several hundred feet long in a single shift and leave the sides straight and smooth with little additional handwork. There are many sizes, makes, and models of trenching machines. They dig with either a digging chain, like a huge chainsaw, or wheel, like a huge saw blade, to cut and pull the earth to the surface. Cuttings are pulled back away from the trench line by a pair of auger flights. The auger flights windrow the cuttings alongside of the trench in a smooth and continuous operation.

Your particular organization may have one or several of these machines in its inventory. We will discuss a typical trenching machine you may find in your unit. As always, become familiar with and perform all the necessary safety inspections before using any equipment.

Preinspection

Before you operate any trencher, complete a preinspection. Like all government vehicles and heavy equipment, you must always thoroughly use the AF Form 1800, Operator’s Inspection Guide and Trouble Report, as covered in volume 1 of this CDC. In addition to routine items on the 1800 like checking fluid levels, belts, and tire pressure, excavators need special inspections.

Make sure the cutting chain, or cutting wheel, is secure to the equipment and in good condition – no missing or broken teeth, or excessive wear. Inspect the raising and lowering hydraulic cylinder and hoses for corrosion, leakage, or other damage. Auger flights need to be clear of debris, well secured, not damaged, and functioning properly. Do not operate the equipment if safety equipment (e.g., roll bar, seat belt, guards) is not installed and operational.

Digging trenches with a trencher

When you arrive at the project site, you may notice two rows of stakes; one row on the centerline of the proposed trench and the other row offset a given distance from the centerline. Do not disturb the offset stakes. They are the stakes you follow while excavating the trench. Information relevant to the depth of the excavation is written on the side of the offset stakes facing the centerline.

For a guide, you can follow the centerline stakes for a distance of several hundred feet ahead of the machine. If you get off center, check the proposed trench line by referring to the offset stakes.

To properly dig a trench, position the trencher parallel to the centerline stakes with the stakes directly under the front of the trencher. Position the digging chain so it's centered over the first centerline stake. With the trencher positioned directly in line with the centerline stakes, a straight trench is assured. If the trencher should move to either side of the stakes, you can bring it back into alignment by gradually steering the trencher in the desired direction.

Check your grade (trench depth) frequently by using a straight board, a carpenter's level, and a measuring stick. Place the level on the board and raise or lower the end of the board opposite the stake until the level indicates the board is level. This measurement should correspond to the amount of "cut" indicated on the stake. All of the stakes will be "cut" stakes. Always try to excavate to the depth specified on the stake. It is better to excavate one or two inches below the grade than it is to not excavate deep enough.

On projects where hub stakes are used, place the board on the top of the hub rather than on the ground to obtain the correct measurement. A hub stake is a wooden stake or pipe that is set in the ground with a tack or other marker to indicate an exact position or elevation. The hub stake is driven into the ground until its top is a definite distance from the bottom of the proposed trench. This distance is indicated as the "cut" on the grade stake, which is set next to the hub stake. Usually, a set of guard stakes protect and identify the hub stake.

Procedures for operating a small trencher

The typical trencher is ideal for light work such as shallow trenches for sprinkler systems, gas lines, water lines, and electrical and communications lines (fig. 3–1); don't let its size fool you. Most of these machines, if equipped properly, can dig trenches up to 8–10 inches wide and four feet deep. Check the operator's manual or appropriate TO for operating parameters and capacities.

Figure 3–1. Typical trencher.

The trencher also has an integrated backhoe bucket use to excavate areas where the trenching unit can't reach or it would be impractical to use. An example of an instance where you would use the backhoe would be when trenching up to a communications box. You would initially excavate in front of the box with the backhoe to expose the exit point for the lines, and then turn the machine around and trench out from it.

When trenching, move the trencher forward to keep the cutters loaded with soil but not so fast or so slow as to stall the machine. Usually, the cutters run at a uniform rate with the ground speed adjusted as necessary. Since the resistance of soil can change, you need to keep alert and be ready to make adjustments.

To determine your chain speed, use the most important factor in any trenching operation; the type of soil. Trenching production is usually increased when trenching in normal soil with the machine placed in third gear. Wet or sticky soils require a faster chain speed to get soil off the chain.

Normally, you can operate the trencher for short periods of time in fourth gear if you are trenching in sticky soils. Trenching in harder soils (containing rock) is usually more successful in second gear. The lower gear allows the cutters to work at a slower speed so they can break through the rock. Use these general operating procedures when excavating small trenches:

1. Lower the trencher (cutting chain) into the ground until it reaches the desired depth (fig. 3–2).
2. After you reach the desired depth, use the appropriate gear for the soil conditions and move the tractor forward. Remember, the depth of the cut and type of soil determines your forward speed.
3. If an object becomes lodged in the cutting chain, stop the operation. Place the transmission in reverse and slowly release the clutch. With the chain now operating in reverse, the object should be dislodged. If you cannot dislodge the object, raise the chain, shut down the trencher completely, and remove the object.
4. Keep the trench as straight as possible. To do this, place a stake at the end of the trench line and during your forward movement; sight the stake line along the center of the hood. If you need to excavate a long trench, you may have to place more stakes in the ground to ensure you follow a straight line as stated earlier.

Figure 3–2. Digging with a trencher.

Once the machine is in motion, your prime role is observation. Make sure the trencher continues along the predetermined trench line and be alert for obstructions. Most trenchers have several operating speeds. These variable speeds were built into the trencher so you can select the proper speed for the different soil conditions and digging depths. As you gain experience, you'll be able to tell by the "feel" of the trencher when an excessive strain is being placed upon it.

On a job where you know the location of an obstruction, stay at least one foot away from it. It is a lot easier to use a shovel to clear around an obstruction than it is to risk damage to the trencher or a utility line. Replacing damaged pipes, lines, and so forth can be expensive.

When the chain is moving rapidly, the cuttings can be thrown with considerable force. Most of the pieces hit underneath the trencher and fall to the ground, but others may be thrown a considerable distance depending on the chain speed. These pieces can create a hazard to someone who is close to the chain. Be sure personnel stay clear when the trencher is operating to avoid injury.

After your trench is dug and the utility lines are laid, your next step is to backfill the trench, or fill it back in with the material you dug out. To prevent damage to the utility lines, cover them with at least 12 inches of sand or other select fill. Normally, we do backfilling in first gear, at a low-engine speed, using the front-mounted blade (if equipped). Begin backfilling by positioning the machine parallel to the windrow. Angle the backfill blade either to the right or left. This allows you the ability to backfill the trench from any direction. When you backfill the trench, make two or more passes into the material rather than trying to move all the material at one time. It's best to leave a small windrow over the trench to allow for settling.

221. Backhoes

The second type of excavating machine we will discuss is a *backhoe*. The backhoe uses a bucket to cut, raise, and swing the material to the side for dumping. You must guide the machine through each step of the digging cycle and continuously repeat the cycle throughout the work.

The backhoe attachment is mounted on a typical industrial tractor (fig. 3–3); however, backhoes are built to be used primarily for the rear bucket. The primary use of a backhoe is to dig below ground level. It has the capability to excavate very hard material because we use the weight of the boom and the power of the hydraulic system to force the bucket into the material. It is limited in digging depths by the length of its boom and dipper stick. Some backhoe models have extendable booms which can extend the reach of the boom several feet.

The backhoe disposes of the material by either loading it into trucks or by dumping it onto piles commonly called spoil banks. The lengths of its boom and dipper stick also limit the backhoe dumping range.

You operate the backhoe unit from a control station located at the rear of the backhoe. To add to its versatility, the front of the machine is equipped with a loader bucket. Basically, this machine is designed to function primarily as a backhoe but may be used as a lightweight loader. You can easily reach the backhoe tractor engine throttle from the rear-control station.

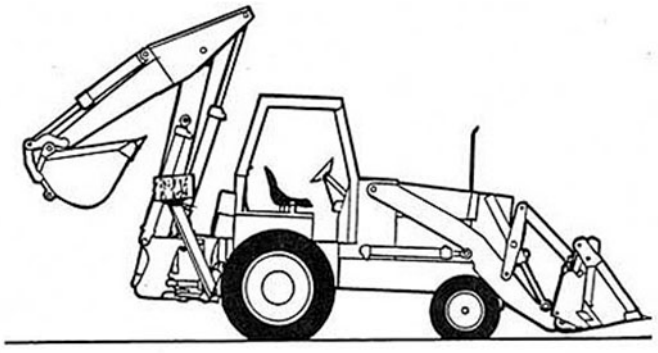


Figure 3–3. Backhoe.

The backhoe is operated by seven hydraulic cylinders. Two of these cylinders control the stabilizers (located on the superstructure behind the rear wheels) to level the machine and give it rigid support. The remaining five cylinders control the operation of the swing, boom, dipper stick, and bucket. These cylinders are operated by control levers or joysticks located on the rear control station and receive operating pressure from the tractor's hydraulic system. You operate the swing unit with two cylinders that provide a fast-controlled swing of the backhoe boom.

You control these cylinders with either two-foot pedals (right and left swing) or an optional hand swing integrated into the control sticks or the joysticks.

The lift cylinder raises or lowers the boom, the dipper cylinder moves the dipper stick, and the bucket cylinder positions the bucket (curls it in or out). You can operate all of these cylinders individually or concurrently with the control levers at the control station.

For most work done on base, you normally drive the backhoe to the work site. After arriving at the work site, you maneuver the backhoe to center it on the trench line with the rear wheels facing the starting point. You use the operator's seat for both loader (normal operations) and backhoe operations. To change the position of the seat, pull up and swing the seat around to the rear until it locks in place. Lower the stabilizers until they are firmly on the ground, applying enough pressure to raise the rear tires off the ground. Leaving the rear tires on the ground reduces backhoe's stability and causes unnecessary weight to be placed on the rear tires. If the ground you are working on is uneven, extend one stabilizer further to level the backhoe. You may need to put a block under the pad of the stabilizer on the low side to aid in leveling.

NOTE: For the following information, assume a specific backhoe is represented. It may not represent the backhoe at your unit and is presented as general information only. Become acquainted with the backhoe at your unit and its operational characteristics.

Before you can begin backhoe operations, move the boom out of the TRANSPORT position. To do this, hold the boom lock handle and move the boom control lever to the UP position (fig. 3–4, view A). When the boom starts to move over the center, raise the transport lock using the lock handle (fig. 3–4, view B).

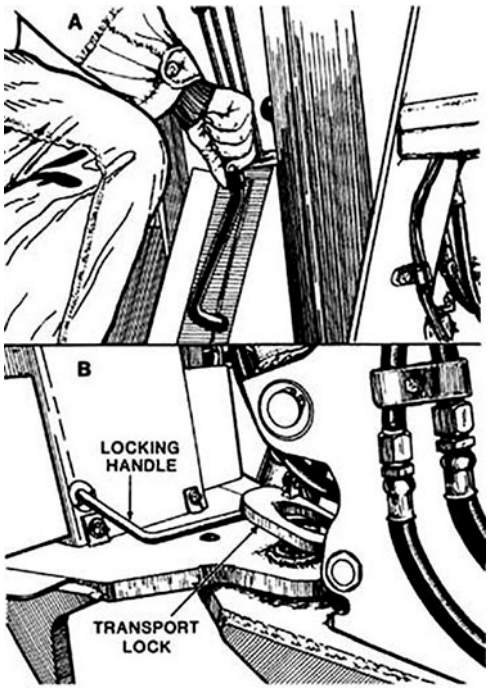


Figure 3–4. Backhoe transport position.

Once the transport lock is raised, move the boom control lever to the DOWN position and lower the boom. As you lower the boom, position the backhoe with the boom at an approximate 45 degree angle. The bucket should be slightly curled and touching the ground (fig. 3–5) as shown.

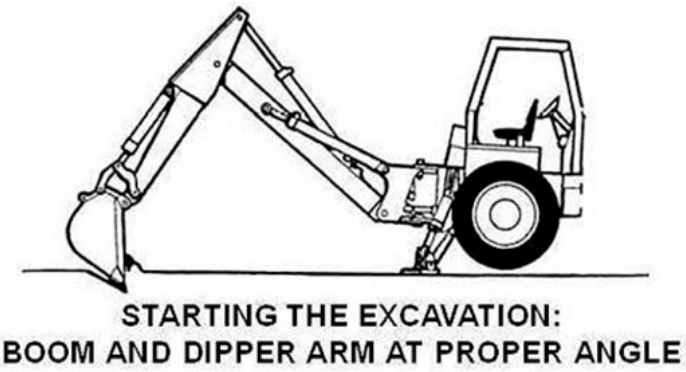


Figure 3–5. Boom at 45 degree angle.

With the backhoe in the position, you are now ready to dig. Digging with a backhoe is a process with a few steps that happen in a cycle. The basic cycle is to make the cut, raise the bucket, swing the material to the side, then return. Within each step of the cycle, there are important things that need your attention. Let's look at them more closely.

1. To start the cycle, pull the dipper back toward the machine and at the same time, raise the boom. This will ensure a level bottom to your excavation.
2. As the dipper gets halfway through the digging cycle, curl the bucket and continue the cycle.
3. Position the bucket teeth parallel to the path the bucket follows during the cycle. In other words, do not curl the bucket too much during the cycle as it will have a tendency to ride up onto the material without cutting into it. This allows for the cutting edge of the bucket to cut and penetrate the soil, filling the bucket and being more efficient.
4. If the bucket stalls, raise the boom slightly.
5. When you complete the pass, finish curling the bucket, raise the boom, and swing it toward the dumpsite. It is your responsibility to be sure the work area is clear of all equipment and workers. If someone is in the area, ground the bucket until the person moves, and never swing the boom or any part of the backhoe over an individual.

CAUTION: Use extreme caution and safety when swinging the unit to one side. The boom has a tendency to swing fast and can catch you or someone in the vicinity off guard.

6. As you reach the dumpsite, extend the dipper over the site and dump the bucket (curl it out) at the same time. If you are going to load trucks, swing the dipper over the back of the truck and not over the cab.
7. After the bucket is dumped, swing and lower the boom and extend the dipper at the same time.
8. When the bucket is over the excavation, stop the swing and lower the bucket. Now you are ready to start the cycle over again.

Once you finish a section, it is not uncommon to reposition the machine using the backhoe unit. To start out, point the front tires straight ahead, raise the front bucket off the ground, and check to ensure the area in front is clear. Then, raise the boom and position the dipper stick almost vertical but leaning slightly toward the back of the machine. Next, lower the bucket so the teeth are on the ground, and then, raise the stabilizers just high enough to clear the ground.

CAUTION: Make sure the boom is just touching the ground when you lift the stabilizers. The rear of the machine could end up teetering on the bucket, creating a dangerous tipping situation.

Operate the dipper stick and boom and SLOWLY push the machine ahead. You can also move the backhoe from side to side by rotating the boom from left to right or by positioning the boom and dipper

stick in the direction you want to go. Lower the bucket until the rear tires are raised off the ground and swing the backhoe left or right to the desired position. After the machine is back in line and in the position you want, lower the front bucket, lower the stabilizers, and continue your operation.

After you are through excavating for the day, reposition the boom back into the transport position following these steps:

1. Raise the boom high enough to curl the bucket and completely pull in the dipper stick.
2. Continue to raise the boom to the vertical position.
3. When the boom reaches the OVER CENTER position (the boom is vertical and all the way into the machine), quickly reverse the control lever to the DOWN position. If you time this properly, the boom will continue to move forward against the stops, and the boom will lock in place (fig. 3–6).

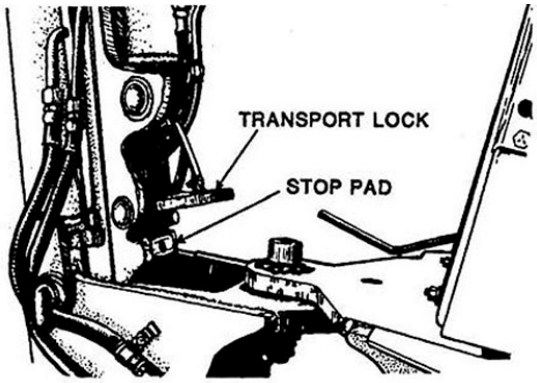


Figure 3–6. Locking boom in place.

For other backhoes, it is a matter of raising the boom until it stops and locking it into position. Regardless of the backhoe you operate, they will all have a carry position.

Backfilling

It is tempting to use the side of the backhoe bucket to backfill a ditch or trench. It also seems easy to use the load bucket all the way in the dump position. DO NOT do either of these things. The equipment isn't meant to be used that way and can be seriously damaged.

The procedures for backfilling with the front bucket are the same as those for the front-end loader:

1. Always begin with the equipment positioned at a 90° angle to the excavated area.
2. Lower the bucket to grade level, place the transmission in a low forward gear, and then push the material ahead.
3. If the material is too heavy, fill the bucket and dump it in the trench or backfill on an angle from a corner of the material. If you try to push too much at one time, you'll cause the tires to spin. This results in excessive tire wear, can damage the surrounding area, or you might get stuck.
4. When the bucket reaches the trench, raise and dump the scooped material.
5. After you are through backfilling, level the area by lowering the bucket and pushing the lift control lever all the way forward into the FLOAT position. The bucket will freely follow the contour of the ground as you back over the area.
6. The final step is to compact the trench or excavation. You can use the tires of the backhoe or, if the excavation is part of a larger project and needs to have a specific density to build on, use available compactors to ensure you reach the desired density.

Loading materials

So far you've read how the backhoe can dig and backfill a trench, but as we mentioned earlier, the backhoe is a multipurpose piece of equipment and can be used to load and unload construction material as well. We primarily use the front and rear buckets of the backhoe to load materials.

Front bucket

Procedures for loading material with the front bucket of a backhoe are basically the same as those we use with a front-end loader; they are as follows:

1. Begin by approaching the material with the bucket lowered, level, and flat on the surface.
2. Place the direction-control lever in the FORWARD position and approach the material. As you make contact, increase the acceleration; however, do *not* let the tires spin as you proceed into the material; this causes undue wear on the tires and creates ruts. Roll the bucket back until it is full or is raised out of the material.
3. Once the bucket is full or raised out of the material, decrease the engine speed and back out and away from the material. Always travel with the bucket low to the ground until you are ready to unload the material. As you approach the dump truck, raise the bucket to the desired height, and unload the material by tilting the bucket forward.

NOTE: Be careful loading dump trucks with high sides as typical backhoes with small front tires; like that of an industrial tractor, they tend to be unstable when a full bucket is raised to its maximum height. A tipping situation could happen quickly so take great care and slow down.

Rear bucket

Loading excavated materials directly into a dump truck is ideal when working in restricted areas or when preventing damage to improved grounds. When that is the case, you may need to load a dump truck using the backhoe rear bucket. To load materials:

1. Ensure the dump truck operator is out of the truck before you begin.
2. Extend the boom and dipper to reach the desired excavation starting point. Curl the bucket three to five inches to create a better digging effect. At this point, the machine is ready to begin excavation. Bring the dipper in toward the machine while slowly raising the boom.
3. When you reach the end of the excavation, curl the bucket to water level full. This simply means the bucket is not "heaped" full and will keep loose material from coming out of the bucket. Raise the bucket until it is 12 inches to 18 inches off the ground. Swing the bucket until it is 12 inches to18 inches away from the dump truck.
4. Using the dipper and boom controls, raise the bucket until it is above the dump truck while continuing to swing the boom until the bucket is over the bed.
5. Dump the spoil evenly into the truck. Swing back until the backhoe attachment is 12 inches to 18 inches away from the dump truck.
6. Lastly, return the bucket to 12 inches to 18 inches from the ground and swing back to the excavation. Continue these procedures until the area you're digging reaches the required specifications. Always be extra alert and cautious when completing these tasks.

The backhoe unit can also be used for loading and unloading light materials, or lowering pipe into trenches. Before using the backhoe as a crane to lift heavy items, be sure to put the boom in the TRANSPORT position, and always lower the stabilizers (fig. 3–7). If needed, remove the bucket to lighten the weight on the dipper stick. As with all lifting operations, there are a number of safety factors to consider such as wearing the proper PPE and keeping unnecessary people out of the area. Also, make sure you read the owner's manual thoroughly to understand the backhoe lifting capabilities. Some backhoes even have a load chart explaining these capacities in different configurations.

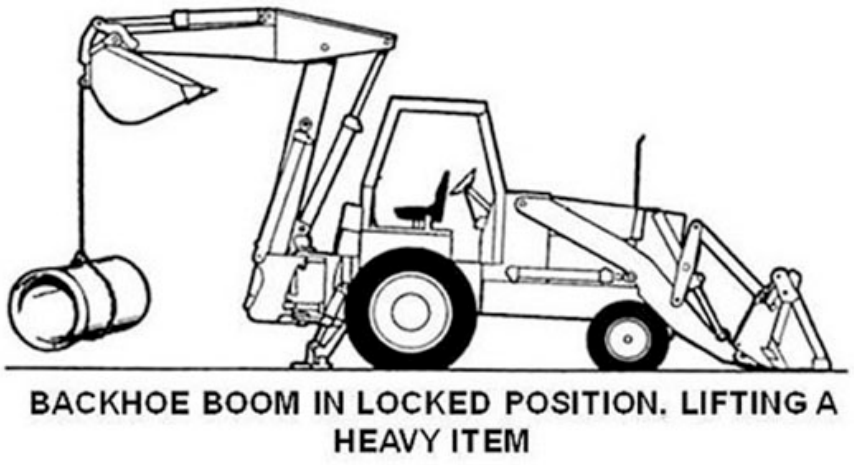


Figure 3–7. Loading heavy items with the backhoe boom.

Here are some safety precautions when operating a backhoe:

- Never stand under a raised bucket to hook or unhook the load. Always lower the bucket first.
- Always be sure the hooks or slings are correctly placed and secured before raising the load.
- Keep everyone away from the suspended load, and never move the load over a person's head.
- Do not swing the load too far to one side, as this can cause the machine to tip.
- Avoid swinging the load too fast, as this can cause the load to start swinging out of control.
- Always know the weight of the item that is being lifted or lowered before attempting to place the item above head level or lowering into a trench.
- Refer to the TO or owner's manual for weight capacity for backhoe boom.

Post inspection

At the end of each day, you must perform a post inspection. The main reason for this check is to observe any missing, damaged, or unserviceable parts or components and to alert maintenance personnel of any problems that may have developed during the day. Remember, a good post inspection includes cleaning, lubricating, fueling, and documenting any mechanical discrepancy.

222. Excavators

The third and final type of excavating equipment are excavators. Yes, the previous two do excavation, but an *excavator* seriously handles very heavy projects. They use the same principle as the backhoe but use different controls to operate the machine. The controls usually look like "joysticks." Joysticks in heavy equipment can be better than levers because they create more natural action. When you move the control lever diagonally between two functions, both functions are performed simultaneously and seem more like natural movements.

Just like backhoes, excavators come in a variety of shapes, sizes, and capabilities. The biggest difference between types in the AF is whether they have tracks or wheels. Each type has advantages and disadvantages depending on the task.

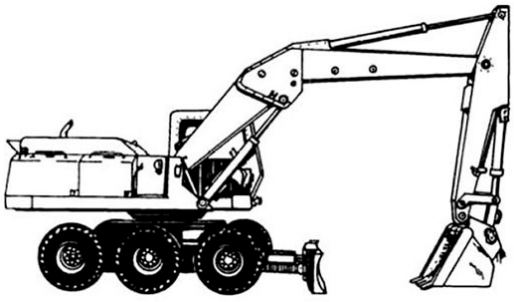


Figure 3–8. Large, rubber-tire excavator.

Large, rubber-tire excavators (fig. 3–8) have three sets of tires. They are much better than tracked machines for RADR because they are

lighter weight and more easily transportable. Besides that, they can quickly break out and remove old concrete, excavate subgrade, backfill, level material using the dozer blade, and compact fill material. This multipurpose piece of equipment combines the functions of an excavator, dozer, and loader into one machine.

The rubber tires also allow them to operate with self-propelled wheel mountings at up to 10 mph on roads, making it highly mobile. Despite their weight and size, even with stabilizers, they can be less stable on loose material than their tracked counterparts.

Figure 3–9. Typical tracked excavator.

Tracked excavators (fig. 3–9) can be more stable on loose soil and are generally better for very large excavation projects like creating a new runway or digging a basement for a dormitory. At your home station you're probably more likely to see these. Aside from the obvious difference of the tracks, the tracked excavator has to be hauled to the jobsite, and they normally do not have dozer blades attached.

A third type of excavator is the smaller, 4-wheeled excavator (fig. 3–10). These have two sets of wheels and weight far less. Less weight means they can travel on normal roads at up to 25 mph. They have dozer blades like their larger wheeled cousins and usually incorporate stabilizers making them almost unshakable. In the future, these will be the go-to machines for RADR tasks.

Figure 3–10. Smaller, 4-wheeled excavator.

The last excavator type has become increasingly popular due to its small size and maneuverability. The miniature excavator (fig. 3–11) is easily transportable and can be adapted to complete different job types through its use of a multitude of attachments. You will probably never see one of these doing crater repair, but you'll see a lot of them un-earthing broken water lines, small trenches, or anywhere needing nimble, effective digging.

Figure 3–11. Miniature Excavator.

Like the backhoe, the excavator is made of three structural sections: the boom, dipper stick, and bucket. These three sections are hinged together with the boom hinged to the excavator frame. Combined with a positive digging action and a rigid control of the bucket, the excavator has the ability to dig accurately through most of the hardest materials. Not only is the excavator designed for heavy excavating and precision digging, we can also remove and replace different attachments for a multitude of jobs.

The biggest difference between the backhoe you just learned about and the excavator is in their construction. With the backhoe, the operator is in a stationary position while the boom and bucket swing from side to side. Though smaller and lighter, the backhoe is still a capable and powerful machine. The excavator is a full-revolving unit with the operator swinging with the boom and bucket. It is a powerful demolition tool with the ability to push and pull forcefully. In this lesson, we explain the basic excavator operations.

Preinspection

Due to the complexity of most excavators and their components, more time is needed to complete the required preinspection before use on a job site. Use the same format as required with all equipment, but due to the size and relative location of the inspection compartments, this inspection takes more time to complete safely. You must climb up onto the machine, and as such, you need to be careful on catwalks and ensure you have a good hold.

Procedures for operating the excavator

You must have an approved AF Form 103 before you begin excavating. Excavating begins by positioning the boom and dipper stick at a 45-degree angle with the bucket slightly curled in and touching the ground. You start the digging cycle by pulling the dipper stick back toward the machine.

As the dipper stick begins to work its way back, begin to curl the bucket. If you want to avoid going too deep, slowly raise the boom while the dipper stick goes throughout the cycle. This keeps the dipper stick from burying the bucket too deep. If you want to improve penetration, depending on the angle of the bucket, put down pressure on the boom. After the bucket is filled, stop the cycle of the dipper stick, raise the boom, and swing it to the unloading site. Dump the material by raising the dipper stick and uncurling the bucket. Swing the bucket back over the excavation, and you are ready to start the cycle over again.

Typically, you move the excavator by using two pivoted foot pedals. To place the excavator in forward motion, push the front of both pedals down. To travel in reverse, push the rear of both pedals down. You also turn the unit using these same two pedals. Push the front of the left pedal down, and you'll turn right; push the front of the right pedal down, and you'll turn left. In a confined area where you need to pivot the machine, fully press the front of one pedal and the rear of the other.

Pushing the right pedal all the way forward and the left pedal backward pivots the machine to the left. Pushing the left pedal all the way forward and the right pedal backward pivots the machine to the right. When you want to stop the excavator, just release the pedals; the transmission stops and holds the machine.

To help you adapt to the different types of operating conditions, you can adjust the travel speed of the excavator by using the propel speed switch located inside the operator's cab. This switch provides you with three separate speed settings for moving forward and backward. Position one is the slowest speed; use it for maneuvering in confined areas or when grading. Position two is for maximum traction power and can be used for maneuvering while transporting, and position three is for normal transporting. Other excavators simply incorporate a hydrostatic transmission. The more you push the pedal, the faster you go.

Digging large excavations

We use both the backhoe and the excavator to make large excavations for footings or stem walls, large tanks, or any other square- or rectangular-shaped job where the digging cannot be completed without moving the machine. You use this equipment extensively for digging wide trenches to lay water and sewer pipe; however, when digging square- or rectangular-shaped areas, the procedures may vary with the shape and size of the job. Restrictions caused by surrounding buildings or other special requirements may dictate the disposal of the spoil. In all cases, when using the backhoe or excavator, the starting point and digging sequence must be properly planned so the equipment can conveniently work itself out into the clear. Improper procedures can not only trap the excavator but can lead to situations where the excavator cannot be positioned to complete the job. In this situation, a lot of digging by hand may be required to complete the excavation. Additionally, if the job is not planned properly, you may need to incorporate additional pieces of equipment to finish the job causing delays.

An acceptable starting and digging sequence is shown in figure 3–12. Remember that you lose a lot of digging time each time you reposition the excavator. Plan your digging sequence so that a maximum amount of spoil is excavated before you must move the excavator to the next position.

Let’s say that the first cut is to be made on the west line (fig. 3–12, view A). The starting point of the machine is on the west line at the point where the boom and dipper stick reach the northwest corner. The machine and boom are lined up 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 trench along the west cutting line. Dig the trench to its full depth and grade. After you dig much of the west wall from this position, swing the boom to reach near the center of the north cutting line. As you see in figure 3–12, view A, make the second cut by digging a trench back from the north wall. Then, remove the spoil left in the angle formed between these two trenches. Remove the spoil in layers until you reach the bottom.

Move the excavator back into the second position as shown in figure 3–12, view B. Continue digging in the same steps you used in position one. Dig the trench first along the west line. Swing the boom around to cut the angle trench, removing the spoil to grade. Continue digging in this manner until you reach the south line.

Move the excavator to the unexcavated portion of the south line shown in figure 3–12, view C. Here, place the bucket in the excavation at the southwest corner to begin the trench along the south cutting line. Again after you dig the trench along the cutting line, swing the boom toward the center to remove as much spoil as possible from this position.

Continue to move the excavator around the excavation, repeating the digging steps until all four cutting lines are cut and the spoil removed. To make the final cut and to remove the spoil, you may have to position the machine at the edge so the bucket can dig straight up; however, you cannot do this unless you know the soil type has good bearing qualities. Cave-ins will result if the soil will not support the weight of the excavator.

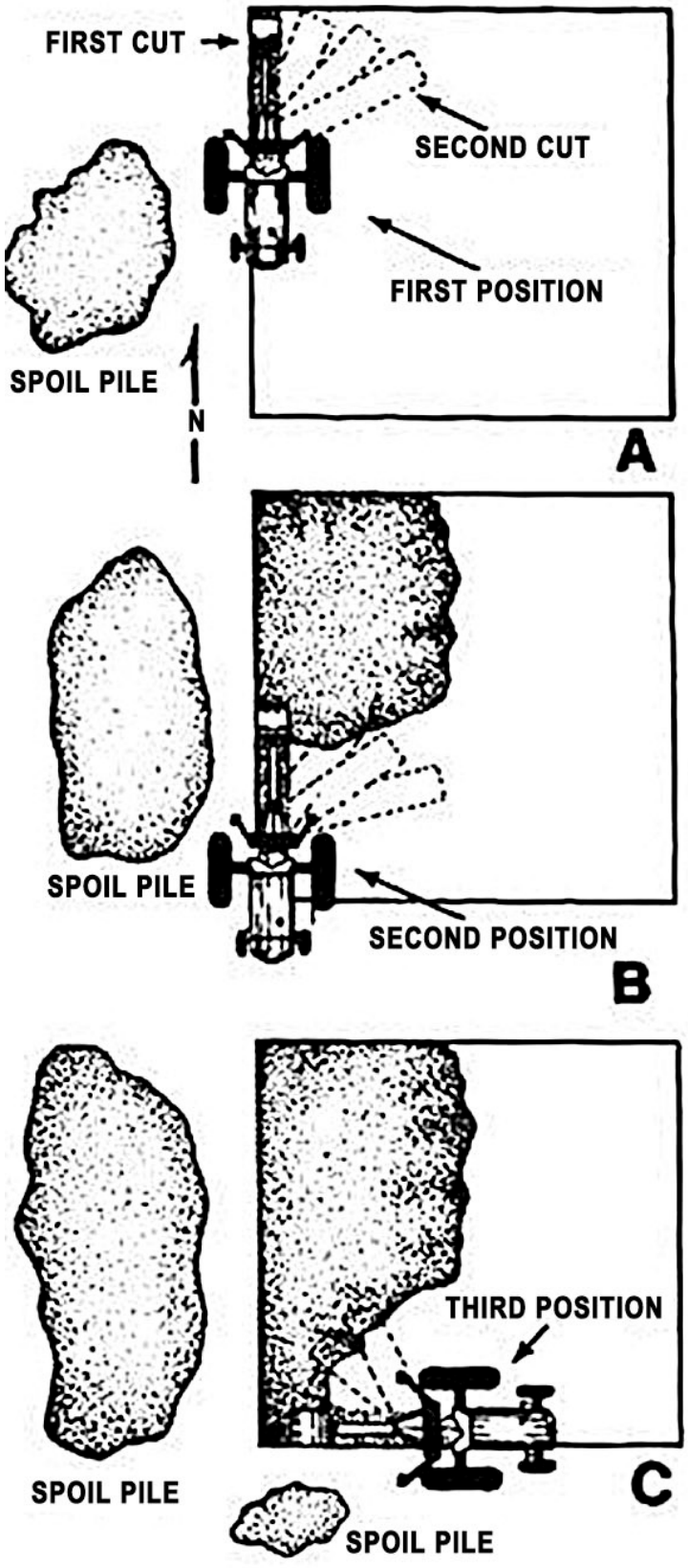


Figure 3–12. Large planned excavation.

Use of a bulldozer blade

A unique option with some excavators is the frame-mounted bulldozer blade shown previously in figures 3–8 and 3–10 of the wheeled excavator. Figure 3–13 shows a closer detail. This blade is excellent to level and smooth out the work area or clear loose rocks away from its path. It also provides additional protection to the undercarriage from large rocks that might be pulled up toward the front of the machine while digging. Additionally, it adds some stability to the machine while actively digging. To make backfilling easier, you can angle the blade to the right or left, tilt it to the right or left, or put it in the float position. Use the float position mostly when back dragging and smoothing out an area. To maintain good control of the blade, place the excavator propel speed switch in position one (or a low overall ground speed). When you finish and are ready to travel, be sure to raise the blade. To help you avoid damage from raising the blade too high and accidentally swinging the upper structure into it, the unit is equipped with a blade/swing interlock switch. Engage this switch to prevent the upper structure from swinging and hitting the raised blade. To resume the swing operation, lower the blade until the blade/swing interlock switch disengages.

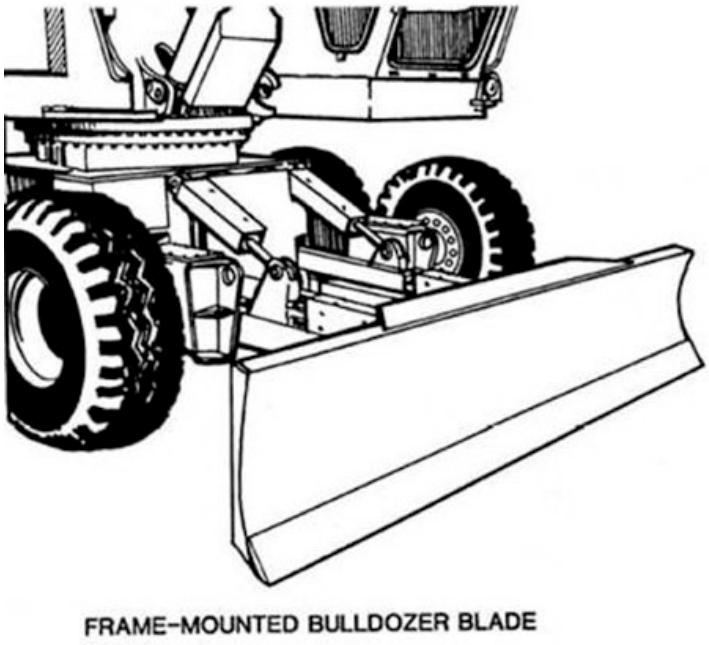


Figure 3–13. Frame-mounted bulldozer blade.

Before your daily operations, be sure to inspect the cutting edges for wear and tear. It is your responsibility to change the cutting edges before they wear down into the moldboard.

WARNING: Never, under any circumstances, change the cutting edges with the engine running.

When changing the cutting edges, the blade will only come down under the power of the engine and cannot accidentally drop; however, don’t take any chances. Always be aware of safety precautions and block the blade assembly for added safety. Remember, you can never be too safe.

223. Attachments and other operations

Different types of excavator attachments such as the impactor, compactor, and bucket can greatly increase the versatility of the machine. Quick couplers allow for instant changes, giving you maximum use of the equipment and the flexibility you need to perform a multitude of jobs.

Before you install or remove any attachment, be sure the excavator is resting securely on solid level ground. To install an attachment on a typical excavator, follow these steps:

1. Insert the hook onto the attachment's cross member (fig. 3–14, view A).
2. Extend the bucket cylinder until the rear connector engages the aligning bearing (fig. 3–14, view B).
3. Raise the attachment completely off the ground. Insert the mounting pin into the quick coupler, and install the retaining pin back into the mounting pin.
4. Depending on the attachment, connect the two hydraulic hoses.

To remove an attachment, follow these steps:

1. Depending on the attachment, disconnect the two hydraulic hoses.
2. Remove the retaining pin from the mounting pin.
3. Remove the mounting pin from the quick coupler (fig. 3–15).
4. After you remove the mounting pin, take pressure off the bucket, retract the bucket cylinder, and remove the attachment.

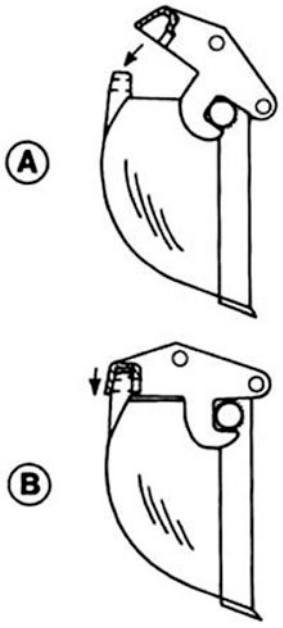
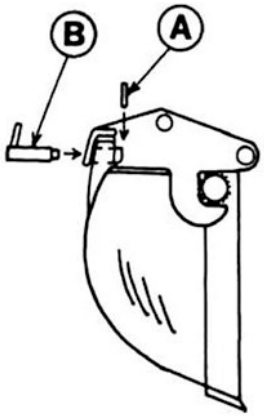


Figure 3–14. Installing attachments.

Impactor

The power to operate the impactor comes from the hydraulic pressure supplied by the excavator through lines running to the end of the dipper. Inside and to the left of the operator's seat is an attachment control pedal. With the impactor perpendicular to the work surface, depressing the pedal activates the impactor. During operation, start breaking the pavement close to the defect—this is where the pavement is weakest and easier to break. The rate of demolition with an impactor varies with the nature, quality, and area of material to be broken. Always exercise safety when you use the impactor. People in the area must wear ear protection and some type of eye protection.



A. RETAINING PIN
B. MOUNTING PIN

Figure 3–15. Removal of retaining/mounting pins.

Compactor

It is not always easy or practical to use rollers around manholes, next to buildings, or in trench bottoms. The compactor attachment makes it possible to tamp base course and other materials in these areas where space is restricted. The compactor uses the same power supply as the impactor. To operate, keep the compactor perpendicular with the surface and press the attachment control pedal.

As you compact base course materials, do it at the optimum moisture content to obtain maximum density. A tightly compacted base course distributes the load evenly over the whole area. The advantages of the compactor are as follows:

- It compacts the surface.
- It helps seal against evaporation of internal moisture.
- It protects the surface from entrance of new water allowing you to continue work even after a rain.

Lifting/positioning loads

There are many ways to lift loads using the excavator boom, but as with any lifting procedure, the danger of unstable loads dictate that unessential personnel keep clear of these situations.

Before lifting a load, ensure you know the weight of the item being lifted. Most excavators have a load chart plate on the outside of the cab for reference. Also ensure participating ground personnel are wearing hard hats and are well aware of your intended movements. Load balance is a critical point. An object only needs to be a few inches off the ground to tell whether it's balanced. Also, when swinging a load, make slow movements. Fast movements place undue stress on everything, perhaps causing the *weakest link* to break. This is where your ground guide plays an important role. Their job in conjunction with the equipment operator is to keep essential personnel abreast of what's going on at all times.

Transporting an excavator

Sometimes it isn't possible to drive the excavator to the next job site. In this case, you load it onto a trailer and haul it to the new location. Be sure to check the width of the trailer before loading the excavator. If the trailer is too narrow for the rubber-tire excavator, reverse the wheels for the machine to set securely onto the trailer. To reverse the wheels, remove the wheels off the hubs, and then, turn and mount the wheel with the deep hub sides in towards the vehicle.

For tracked excavators, make sure your trailer will handle the load and plan appropriately for a wide load. Also ensure the boom of any excavator you haul is well below the maximum height allowance for the base and the highways you will be driving on. Bring the boom and bucket as far into the machine as possible, and set it firmly on the deck of the trailer so it can be secured with chains. A good rule of thumb is to not let the boom be any higher than the cab of the machine and lower if possible. If in doubt of height restrictions, call your local DOT for assistance.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

220. Trenching machines

1. What is the most important factor in determining the chain speed on a trencher?

2. How do you remove an object that is caught in the digging chain of a trencher?

3. What three items do you use to measure the depth of a trench?

4. Which type of stake is set in the ground to show an exact position or elevation?

5. When you begin to back fill a trench, where do you position the trenches?

221. Backhoes

1. How much down pressure do you apply to the stabilizers on a backhoe?

2. What is the digging cycle of a backhoe?

3. How do you start the digging cycle with a backhoe?

4. When approaching material, how do you position the front bucket on a backhoe?

5. At what point do you raise the front bucket on the backhoe to unload material?

6. What can you do to lessen the weight on the dipper stick when lifting materials?

222. Excavators

1. What are the three functions of the rubber-tire excavator?

2. What three structural components make up the excavator?

3. How do you avoid penetrating too deep when excavating?

4. How do you pivot an excavator when working in a confined area?

5. Why is it important to have a properly planned digging sequence when conducting large excavations?

223. Attachments and other operations

1. When operating the impactor attachment, why do you start breaking the pavement close to the defect?

2. What three excavator attachments can greatly increase the versatility of the machine?

3. What must you do to reduce the width of a rubber tire excavator when loading it on a trailer?

3–2. Shoring and Trench Safety

Shoring is the process of bracing the walls of a trench or excavation in order to prevent collapse. It can also reference the materials used to do the bracing, such as hydraulic shoring (the use of hydraulic cylinders pushing against the walls) along with different materials from steel to plywood and aluminum. Trench shields (or trench boxes) should not be confused with shoring because they only protect workers temporarily from trench collapse and are pulled through the exaction by the excavating equipment. They are not a permanent solution to cave-ins. The trench must be backfilled behind the trench shield.

224. Shoring

Once you start excavating, you must follow some general safety procedures outlined in the OSHA Standard 1926 Subpart P, Safety and Health Regulations for Construction. A primary safety procedure is shoring the sides of excavation, a precaution that prevents cave-ins. Cave-ins have claimed the lives of many workers who neglected to shore the walls of trenches where they were working or who did not shore the walls properly. For this reason, you must assure that all trenches are properly shored and you take all safety precautions.

Soil classification

Since many soils are unable to stand in vertical walls by themselves, trenches must be either side sloped or shored. For this reason, we classify soils according to their stability in a decreasing order. Classification is based on soil properties, performance characteristics of the deposits, and the environmental conditions of exposure. For shoring purposes, the classification of soils is not the same as described in an earlier volume of this CDC.

According to OSHA Standard 1926, Subpart P, soil classification falls under four categories: Stable Rock, Type A, Type B, and Type C soils. Each classification places the soil classification into a hierarchy of stability which is decreasing in order according to soil characteristics. Some soil types overlap categories, so always base your shoring requirements on the lower category.

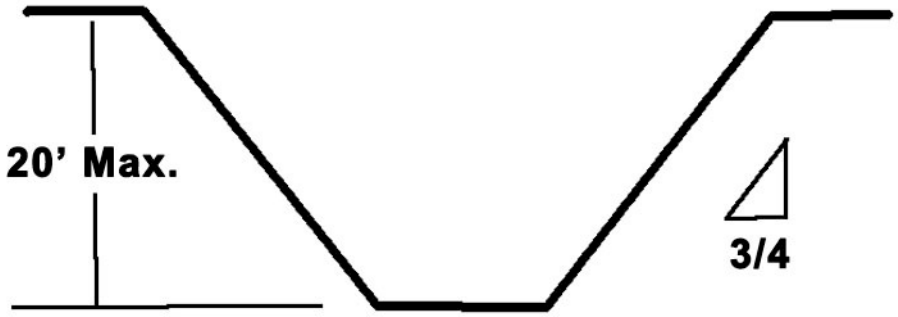
- Stable Rock—Natural solid mineral matter that can be excavated with vertical sides and remain intact while exposed.
- Type A—Cohesive soils with an unconfined, compressive strength of 1.5 tons per square foot or greater. Examples of cohesive soils are: clay, silty clay, sandy clay, clay loam, and in some cases, silty clay loam, and sandy clay loam. Cemented soils such as caliche and hardpan are also considered Type A.
- Type B—Granular cohesion less soils including: angular gravel (similar to crushed rock), silt, silty loam, sandy loam, and in some cases, silty clay loam, and sandy clay loam.
- Type C—Granular soils including gravel, sand, and loamy sand.

Keep in mind that before you can begin shoring construction, you must classify the soil to determine which shoring system to use. You must coordinate this planning with a competent person (normally an engineer within your unit) who has knowledge of shoring applications.

Sloping and benching

Sloping and benching are methods we use to protect workers from cave-ins. Sloping is excavating the trench to form sides which incline away from the excavation (fig. 3–16). The angle in which the trench is to be sloped varies with soil types and environmental conditions of exposure.

Benching is excavating the trench to form one or more horizontal levels or steps with vertical or near-vertical surfaces between levels (fig. 3–17).



SIMPLE SLOPE GENERAL

Exception: Simple slope excavations which are open 24 hours or less (short term) and which are 12 feet or less in depth shall have a maximum allowable slope of 1/2:1.

Figure 3–16. Simple slope—short term.

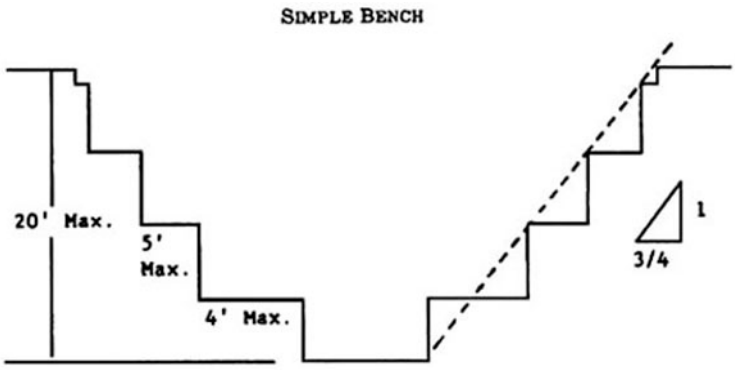


Figure 3–17. Simple bench.

A registered professional engineer must approve all sloping or benching systems. The designs must be in written form with at least one copy of the design maintained at the job site during construction.

The design must include at least:

- Magnitude of the slopes that were determined to be safe for the particular project.
- The configurations that were determined to be safe for the particular project.
- The identity of the registered professional engineer approving the design.

Support systems (shoring)

Each worker in an excavation must be protected from cave-ins by an adequate protective system. These systems must have the capacity to resist, without failure, all loads reasonably expected and applied to the system. Excavations not requiring shoring are as follows:

- Excavations made entirely in solid rock.
- An excavation less than five feet in depth where examination of the ground, by a competent person, provides no indication of a potential cave-in.

Even in an excavation of less than five feet, there is the potential for cave-ins and you should always be prepared to shore a trench to protect workers. Designs indicating the sizes, types, and configurations of materials to be used in shoring must be in written form. At least one copy of this form must be kept on the job site and must identify the registered professional engineer who approved the system.

Materials and equipment used for shoring must be free from damage or defects that could impair their function. Manufactured materials and equipment must be maintained in a manner consistent with the manufacturer's recommendations (shields, shoring members, supports, etc.). When material or equipment is damaged, a competent person must examine the material or equipment to determine its usability. A competent person is defined as one who is capable of identifying any existing or predictable hazards in the surrounding area that are hazardous or dangerous to workers. If the competent person is unable to make a decision, the materials and equipment must be removed from service. The material and equipment cannot be reused until it is approved by a registered professional engineer.

Excavating material no greater than two feet below the bottom of the shoring can be permitted, but only if the system is designed to resist the forces calculated for the full depth of the trench. Workers in a sloped or benched excavation may work at levels above lower workers when the lower workers are adequately protected from falling, rolling, or sliding of material or equipment. For this reason, materials, equipment, and spoil piles must not be placed closer than two feet from the excavation. All excavations 20 feet or less in depth which have vertically sided lower portions must be shielded or supported to a height at least 18 inches above the top of the vertical side, with a maximum allowable slope of 1½:1.

Members of the shoring system are selected using information provided by the engineer to the manufacturer and are based on the depth and width of the trench where the members or system is to be installed. When the soil type, width and depth of trench, and horizontal spacing of the cross braces are known, the size and vertical spacing of the Wales, the size and horizontal spacing of the cross braces, and the horizontal spacing of the uprights can be easily tabulated. Once everything is calculated, you will need to install the system according to the manufacturer's recommendations.

It is not recommended to construct shoring without the planning and approval of an engineer because the dangers are too great.

225. Inspections/safety

A competent person must make daily inspections of the excavation surrounding area, and the protective system used for any evidence or situation that could result in possible cave-ins, failure of the protective system, or any other hazardous conditions. These inspections must be completed prior to the start of each workday and as needed throughout the day. Inspections must also be made after every rainstorm or when increased hazardous conditions exist. If evidence is found that could result in a possible cave-in, failure of the protective system, or any other hazardous condition, remove all workers from the hazardous area until the necessary precautions are taken to ensure their safety.

Safety does not stop with only the open excavation but must also include the area around the site. An excavation of any depth must be secured with safety in mind. Could you imagine what would happen if a small child fell into an open excavation that was not secured? When planning any type of excavation, plan for the "what ifs." Excavated areas, whether they are open for only a day or for

weeks, must have temporary fencing, concrete barricades, or other devices to prevent anyone from being hurt on that job site.

Water hazards

Ground water is a leading cause in trench collapse. The upper portion of the trench may be firm and dry, but a shallow bottom layer may be waterlogged and unstable. The sides of the trench may stand for a short time before becoming undermined by the movement of the bottom layer. Keep in mind, collapse of trenches may happen in minutes, hours, or even days after excavating rather than immediately.

Exceptions may be trenches in loose sand or when semiliquid mud flows into the excavation rather than falling into it. Sometimes surface water or rainwater may enter the trench, especially when the trench is left open overnight. Before resuming operations, remove the water from the trench. For a small amount of water, you can use a bucket to bail the water out; however, the best way to drain a trench is by using a water pump. There are two types of pumps we commonly use: the diaphragm pump and the centrifugal pump. Usually, both are powered by a small gas engine or electric motor.

Figure 3–18. Diaphragm pump.

Diaphragm pump

The diaphragm pump uses a flexible diaphragm to move liquid (fig. 3–18). On the suction stroke, the diaphragm is drawn upward into a concave configuration. This movement of the diaphragm results in a partial vacuum that causes the suction ball valve to unseat and to admit liquid to the pump cylinder. On the discharge stroke, the diaphragm is pushed downward forcing the trapped liquid out through the discharge valve. Thus the liquid is made to move by the reciprocating motion of a flexible diaphragm. Since the diaphragm forms a tight seal in the pump cylinder between the liquid being pumped and the rest of the pump and driving mechanisms, there is little danger of liquid abrasion or corrosion of moving parts behind the diaphragm.

Diaphragm pumps are especially well-suited for pumping mud, slime, silt, and other waste of heavy liquids containing debris, such as sticks, stones, or rags. Liquid strainers are fitted at the suction inlet to prevent large objects from fouling the suction and discharge valves or possibly damaging the diaphragm.

The diaphragm pump is used for dewatering trenches where water or sewer lines are to be laid, dewatering coffer dams or cave-ins, or repairing breaks in water or sewage lines. Two of the most popular types of diaphragm pumps are the mud hog (closed discharge) and the water hog (open discharge).

Because of the nature of the liquids handled by diaphragm pumps, inspection during pump operation becomes particularly important. Inspect the suction inlet strainer often to avoid accumulations of debris that reduce suction efficiency. Most diaphragm pump installations also permit easy access to the suction and discharge ball check valves. Inspect these valve mechanisms frequently to detect scoring, fouling, and improper valve seating.

You may have to partly dismantle the pump to remove large particles from the inlet or discharge part of the pump. If you do, use the manufacturer’s manuals as references. Also, never try to remove debris or service the pump with the motor running.

Centrifugal pump

The basic centrifugal pump has only one moving part—a wheel or impeller that is connected to the drive shaft or prime mover and rotates within the pump casing (fig. 3–19). Thus, the liquid is sucked in at the center or the eye of the impeller (center of rotation) and discharged at the outer rim of the impeller.

Figure 3–19. Centrifugal pump.

The operation of the centrifugal pump is generally similar to the operation of the diaphragm pump.

Centrifugal pumps are also fitted with stuffing boxes and various types of bearings that require periodic operator's maintenance and inspection, so check the operator's manual for specifics to your machine. Because of the impeller, the centrifugal pump is not the best choice for mud and debris laden water.

Before you begin operation, close the discharge stop valve before you start the pump. The reason for closing the stop valve is to allow the pump to work against the sealed discharge and build up an effective pressure head before attempting to move and distribute the liquid downstream. After the pump is up to speed and the discharge valve is opened, it will continue to maintain that pressure head unless the operating conditions change.

There is no danger of building excessive pressure while the pump is running with the discharge closed. If the centrifugal pump were permitted to continue operation with the discharge sealed, it would simply build up toward its maximum discharge pressure, and then begin to churn the liquid; that is, the discharge pressure would overcome the suction pressure, and the liquid would continually slip back to the suction side of the pump. Nothing more would happen except that, the pump would build up heat since the liquid would not be able to carry away heat generated by the moving parts.

In any water pump, debris may get sucked into the inlet hose and cause the water pump to stop. To keep this from happening and jamming moving parts in the pump, put a liquid strainer or a screen over the inlet hose to keep debris out.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

224. Shoring

1. What is the purpose of shoring?

2. What two types of excavations do not require shoring?

3. Define a competent person.

4. When can an additional two feet of material be excavated below the bottom of the shoring?

225. Inspections/safety

1. What does an inspector look for when making daily inspections of the excavation, surrounding area, and the protective system?

2. What is a leading cause in the collapse of trenches?

3. Which type of pump is better suited for pumping mud, slime, or silt?

4. What must be installed at the suction inlet end of any pump to prevent debris from jamming moving parts inside the pump?

Answers to Self-Test Questions

220

1. Type of soil.
2. Place the transmission in reverse and slowly release the clutch. With the chain now operating in reverse, the object should be dislodged. If you cannot dislodge the object, raise the chain, shut down the trencher completely, and remove the object.
3. (1) A straight board.
   (2) A carpenter's level.
   (3) A measuring stick.
4. Hub stake.
5. Parallel to the windrow.

221

1. Enough pressure to raise the rear tires off the ground.
2. Cut, raise, and swing the material to the side for dumping, then return.
3. By pulling the dipper back toward the machine.
4. Lowered, level, and flat on the ground.
5. As you approach a stockpile or dump truck.
6. Remove the bucket.

222

1. (1) Excavator.
   (2) Dozer.
   (3) Loader.
2. The boom, dipper stick, and bucket.
3. Slowly raise the boom while the dipper stick goes throughout the cycle.
4. Fully press the front of one pedal forward and the back of the other pedal backward. Pressing the right pedal forward pivots left, and pressing the left pedal forward pivots right.
5. To conveniently work into the clear so you can complete the excavation.

223

1. Because the pavement is weaker there and should be easier to break.
2. Impactor, compactor, and bucket.
3. Reverse the wheels.

224

1. To prevent cave-ins.
2. (1) Excavations made entirely in solid rock.

   (2) Excavations less than five feet in depth where examination of the ground by a competent person provides no indication of a potential cave-in.
3. One capable of identifying any existing or predictable hazards in the surrounding area which are hazardous or dangerous to workers.
4. When the system is designed to resist the forces calculated for the full depth of the trench.

225

1. Any evidence or situation that could result in possible cave-ins, failure of the protective system, or any other hazardous conditions.
2. Ground water.
3. Diaphragm pump.
4. Liquid strainer or screen.

Complete the unit review exercises before going to the next unit.

Unit Review Exercises

Note to Student: Consider all choices carefully, select the *best* answer to each question, and *circle* the corresponding letter. When you have completed all unit review exercises, transfer your answers to the Field-Scoring Answer Sheet.

Do not return your answer sheet to the Air Force Career Development Academy (AFCDA).

72. (220) While trenching, which construction stakes should *not* be disturbed?
    a. Slope.
    b. Offset.
    c. Blue-top.
    d. Centerline.

73. (220) What does a hub stake indicate on an excavation site?
    a. Exact position or elevation.
    b. Starting point of the project.
    c. Outside boundaries of the project.
    d. Where the windrow should be placed.

74. (220) When using a trencher, the cuttings can be pulled back away from the ditch by using a
    a. bucket.
    b. digging chain.
    c. pair of auger flights.
    d. front-mounted blade.

75. (220) If you know the location of an obstacle or utility where you are trenching, you must
    a. stay at least a foot away from it.
    b. place the trencher into a lower gear.
    c. check the digging permit for the depth of the obstacle.
    d. raise the digging chain and excavate over the obstacle.

76. (221) What factor limits the digging depth of a backhoe?
    a. Type of soil.
    b. Horsepower of the engine.
    c. Position of the digging bucket.
    d. Length of the boom and dipper stick.

77. (221) On a typical backhoe, where do the five cylinders that control the operation of the swing, boom, dipper stick, and bucket receive hydraulic pressure?
    a. Umbilical hydraulic reservoir.
    b. Tractor’s pressure regulator.
    c. Secondary hydraulic system.
    d. Tractor’s hydraulic system.

78. (221) What action do you take if the bucket stalls while you are excavating with a backhoe?
    a. Raise the stabilizers.
    b. Raise the boom slightly.
    c. Change the angle of the bucket.
    d. Increase the engine’s revolutions per minute (rpm).

79. (221) What action do you take if you are operating a backhoe and someone steps in the swing radius of the bucket?
    a. Slow down the operation.
    b. Keep the person in visual contact.
    c. Notify your supervisor as soon as you can.
    d. Ground the bucket until the person moves out of the area.

80. (222) How do you disengage the blade/swing interlock switch on the rubber tire excavator?
    a. Lower the blade.
    b. Release the brake.
    c. Place the blade-control lever in float.
    d. Place the excavator propel-speed switch in position 1.

81. (222) When excavating, where do you lose a lot of your digging time?
    a. Excavating basements.
    b. Refueling the machine.
    c. Reading the offset stakes.
    d. Repositioning the machine.

82. (222) When excavating a large area, if the first cut is to be made on the west line of the project, the starting point should be where the boom and dipper stick reach the
    a. southwest corner.
    b. northwest corner.
    c. southeast corner.
    d. northeast corner.

83. (223) An advantage of using the compactor attachment on an excavator is that it
    a. takes less time to compact the area.
    b. does not affect the surrounding area.
    c. gets into areas where space is restricted.
    d. breaks up the larger particles in the aggregate.

84. (223) What do *most* excavators have to make lifting loads safer?
    a. Excavators cannot lift loads.
    b. Sensitive control levers.
    c. Heavy duty hydraulics.
    d. A load chart.

85. (224) What safety precaution prevents cave-ins during excavation?
    a. Shoring the sides of the excavation.
    b. Putting the material into dump trucks and haul away.
    c. Using another excavator to stabilize the trench walls.
    d. Operating the excavator at lower revolutions per minute (rpm) in unstable soil.

86. (224) What person is defined as one who is capable of identifying any existing or predictable hazards in the surrounding area that are hazardous or dangerous to workers and is typically an engineer?
    a. A supervisor.
    b. An employee.
    c. A common person.
    d. A competent person.

87. (225) What action must be conducted daily at the site of an excavation?
    a. Take soil samples.
    b. Inspections.
    c. Backfilling.
    d. Cribbing.

88. (225) Excavated areas, whether they are open for only a day or for weeks, must have what devices to ensure safety?
    a. Lights.
    b. Fencing.
    c. Road cones.
    d. Caution tape.

Please read the unit menu for unit 4 and continue ➔

Student Notes

Unit 4. Support Equipment

SUPPORT EQUIPMENT IS a broad term used to describe all the additional equipment we use to support the mission that doesn't fit into another specific category. The equipment we will discuss includes water trucks, compactors, industrial tractors, sweepers, asphalt pavers, and equipment used in snow removal and ice control. This equipment is essential to CE operations.

4–1. Surface Preparation and Maintenance

A lot of preparation goes into keeping road and airfield surfaces compacted and dust free. In deployed or austere conditions, making sure operating surfaces are compacted and not too dry becomes a daily maintenance task. During paving projects, making sure the sub-surface material is properly compacted is critical. Whether you are deployed or at home station, if you are involved in any sort of paving project, road or airfield maintenance, you will spend a lot of time either operating water trucks, using an industrial tractor and various compaction equipment.

226. Water truck operations

There are two types of liquid material distributors you'll use in your job—the water truck and the water tanker. Because water tankers are not available at all installations, we will concentrate on the water truck. Just know that if you are tasked with operating a tanker, the systems are the same (filling, spraying, discharge, etc.) just the size and configuration of the tank is different.

Water distributors are normally truck-mounted tanks with a spray bar. They are used for applying water to dry soils, which helps in the compaction process. They can also be used for storing and hauling water or to wash equipment.

Description

The water distributor is commonly referred to as a water truck (fig. 4–1). It's equipped with an auxiliary engine that is used for pumping water from a stream

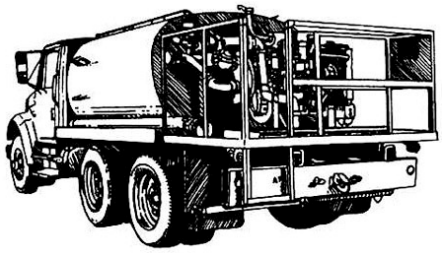


Figure 4–1. Water distributor.

or other source, into the tank, pump water out of the tank, under pressure, through the spray bar or through a hose, or the water can be fed by gravity.

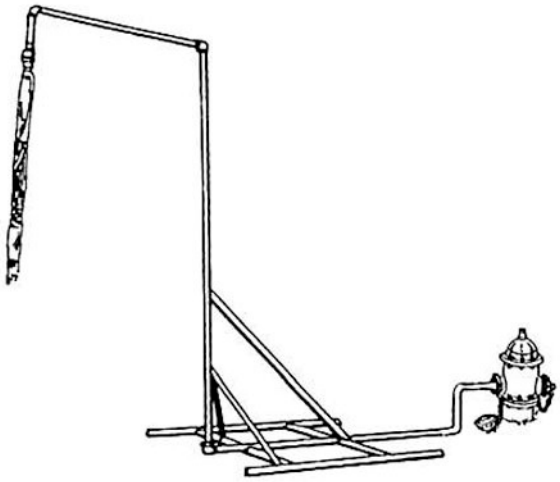


Figure 4–2. Typical water fill station.

Tank filling

Your first task in operating a water truck is to fill the tank. The quickest way to reduce filling time is by using a fill station (fig. 4–2). A typical fill station may consist of a pipe, which has been braced and placed near a hydrant (fire plug) with a pipe connected to the hydrant. The pipe is braced for stability and protection from accidental damage. A short piece of fire hose is connected at the exit end of the pipe to allow a truck to pull under the pipe. The fire hose can then be easily maneuvered into the water tank when filling. When working in the field, you can set up a system similar to the one just described near a stream or lake. Use the auxiliary engine-powered pump to fill the water tank. A more permanent fill stand can be built and connected into a water main operating under the same principle.

Another way to fill the truck is with a fire hose connected to a fire hydrant and run up into the tank. This is a slower method and should be used only under extreme conditions. With water flowing through the hose, the pressure can cause the hose to come out of the tank and possibly hit and injure someone. You can also damage the fire hydrant by using an incorrect size wrench, which can round off the valve nut. If you're unable to close the valve completely, water will constantly drain from the hydrant.

Driving the truck

You must be very careful driving the truck when the tank isn't completely full. The reason is the ballast plates inside the tank are normally designed only to reduce water movement forward and backward. If you make a sudden turn, the water sloshing from side to side may cause you to lose control due to instability. Always be cognizant of the changing loads and how they affect the handling of the vehicle.

Spraying operation

The most important factor in determining how well a soil can be compacted is the degree of moisture in the soil. Sprinkling soil so it will compact well requires you to spray slowly allowing the water to soak in instead of running off. Sprinkle just enough water so the soil will compact well.

High-pressure water can be supplied to the mounted spray bars or water hose using the auxiliary self-primed centrifugal pump mounted on the rear of the truck. If the pump is empty, it may need to have water added (primed) before operation. A diagram mounted on the rear of the truck shows which valves are to be opened or closed when using either the spray bars or water hose. The spray bars can be used for applying heavy concentrations of water for dust control, soil compaction, and soil stabilization. The water hose can be used to assist in washing equipment, fighting fires, and any number of uses where high-pressure water is needed. For safety purposes, eye goggles should always be worn when using the high-pressure water hose and ear protection when working near the auxiliary engine.

Filling the tank using the auxiliary pump

The water truck should be placed as close to the water supply as possible. A standard centrifugal pump is mounted on the back of the truck. Normally, this pump doesn't need to be primed to handle a solid volume of water; however, when the pump is empty of water, it must be filled (primed) before starting.

If air is allowed to enter the intake, the pump loses its suction. Additionally, check your truck for a self-priming pump. In this case, the pump primes itself by bleeding air off through the pump housing until a full volume of water is attained. Once the air is bled off, it will start pumping almost immediately.

Leaks developed while pumping may cause the pump to lose its prime. Even small leaks can prevent a pump from picking up water. For this reason, all air leaks on the inlet side of the pump will need to be guarded against. To prevent leaks, inspect all hose couplings, and tighten down any loose connections.

A pump may also fail to work because of a clogged inlet pipe. To prevent the inlet pipe from getting clogged or allowing an object to damage the pump, a screen should be fitted over the inlet end. Water containing leaves or other organic material can clog a screen easily. Under these conditions, the inlet end will need to be checked and cleared routinely. A pump works best when one or two feet of water is kept over the inlet. In shallow water, dig a sump pit for the pump hose. If possible, line the bottom of the sump with rocks so the inlet doesn't pick up debris or mud from the bottom. If the water is deep enough, try and hold the inlet up off the bottom of the water source.

227. Compaction equipment

Compaction refers to the process of artificially increasing the density of soil. This process involves forcing soil particles closer together and expelling water or air from the spaces between them. The purpose of compaction is to stabilize soil. Properly compacted soil shows a minimum change in shape from weather, time, and the weight of structures, pavement, or traffic. In this section we cover the most common types of compaction equipment: the sheepsfoot roller, steel-wheel roller, and pneumatic-tire roller.

One of the most important phases in the construction of a paved surface is the compaction of the supporting courses underneath the pavement structure. If the soil is not properly compacted, the pavement will settle and fail.

Sheepsfoot roller

A sheepsfoot (or pad foot) roller is the best type of roller for compacting plastic soils such as clay, but it is unsatisfactory for compacting sand, gravel, or crushed rock. Generally, rollers compact soil from the top and work down, whereas sheepsfoot rollers compact from the bottom and work to the top.

Description

The sheepsfoot roller is a round drum fitted with tampers or feet and is towed usually by a dozer (fig. 4–3). Towed rollers may also be joined together side by side; hitched one, two, or three behind one another; or rigged in various ways to compact the most ground in the least amount of time. Sheepsfoot rollers come in various sizes with weights ranging from a couple of tons all the way up to ten tons or more. Some of these rollers are able to have water added in their drums for additional weight.

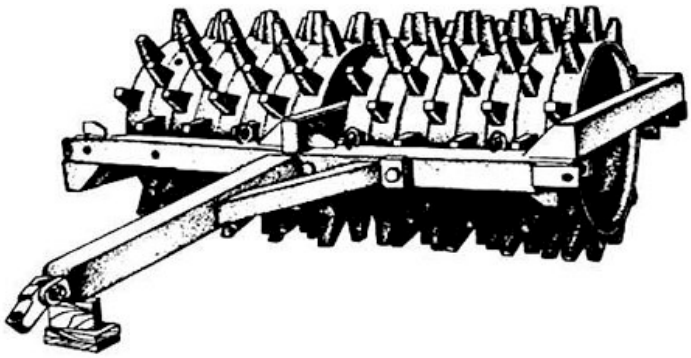


Figure 4–3. Towed sheepsfoot roller.

Additionally, you may be exposed to self-propelled sheepsfoot rollers (fig. 4–4). These rollers are fundamentally identical to the towed type except they are self-propelled. Again, they range in sizes from a couple of tons to ten tons or more, and the drum width comes in many different sizes as well. If you know the operating parameters of the roller, this will determine how many passes are needed to bring the compaction to the appropriate density. This information can be found in the owner's manual or operator's manual and is invaluable for getting the most out of the roller.

Operation

The operation of a sheepsfoot roller is simple. It is merely towed over the ground or driven over the area. On the first pass, the pads penetrate their full length (depending on the soil characteristics of course). Each succeeding pass compacts additional material until the roller feet work to within the upper two inches, indicating that the material is solidly compacted from the bottom up. This action is called “walking out” or “rolling out.” A typical sheepsfoot roller can compact a nine-inch layer of loose soil to 75 percent compaction in 10–12 passes. Be sure you overlap each pass by at least 12 inches so that the material is completely compacted.

Figure 4–4. Self-propelled sheepsfoot roller.

When towing a sheepsfoot roller, work from the outside to the center of the road. Working the center first tends to dish the job, that is, it leaves the center lower than the shoulders. Working from the outside to the center maintains the crown and drainage of the job site.

The sheepsfoot roller leaves one to two inches of loose material at the top of each compacted layer. This loose material assists in bonding successive layers as the roller pushes material of the second layer down into the loose material of the first layer. This process compacts the first layer and the entire second layer (except the top one to two inches). Compaction continues layer by layer until you compact the final layer. Compact the loose material on the top of the final layer with steel-wheeled rollers or pneumatic-tire rollers.

Steel-wheel (vibratory) roller

Steel-wheel rollers are probably the most used piece of compaction equipment in your shop. We use these rollers to breakdown and finish roll flexible pavements and for the finish rolling of subgrades and base courses. They come in a variety of different sizes and configurations. A single drum, pneumatic rear-tire set up would be ideal for base course material and general dirt work. It wouldn’t be ideal for asphalt however, because the rear tires would leave marks or could possibly tear the surface. Also, a dual drum steel wheel roller in 10–12 ton class may be good for some asphalt, but it may be too large for other asphalt mixes. A better choice may be the small 3.5 ton roller. Additionally, these small rollers are adept at getting into smaller areas and can be hauled easily behind a dump truck.

Figure 4–5. Steel-wheel (vibratory compactor) roller.

Description

The basic effect of a roller is to compact material under it by static or dead weight. The wheeled vibratory compactor/roller is a compact double drum vibratory compactor with an operating weight of four tons (fig. 4–5). Each of its drums can deliver over 8,000 lbs of applied force for compaction. With high curb clearance, you are able to compact right up to curbs as high as 9.5 inches.

Operation

These rollers produce a solid and smooth surface under favorable conditions, but may fail to compact low spots that are narrower than the drum because of bridging. The vibrations that are imparted through the steel drum produce a rapid series of impacts that create pressure waves called the "frequency", measured in hertz (Hz). These pressure waves penetrate the soil, setting particles in motion that fill void spaces between soil particles. On most vibratory rollers, you can adjust the frequency to compact different materials. Check your owner's manual for the best settings for the materials you are working with.

To keep the drums clean and free of debris, the roller is equipped with scraper blades. These scraper blades are an integral part of the drum frame and must be in place and securely fastened. Each drum has two blades, an inside and outside assembly. These blades are essential in preventing material from building up and sticking on the drums, which would spoil the smooth surface.

Asphalt is kept from sticking to the rolls by a fine spray of water that comes from the spray bars attached to the machine. Adjust the spray bars to provide a fan-shaped and overlapping spray pattern that completely covers the drum. Ensure the sprayers are operational prior to paving operations. Keep them wet throughout the rolling operation; a dry drum could spell disaster for paving operations. Remember, drive the roller forward onto the asphalt because the drive wheel pulls itself onto the asphalt and prevents asphalt from being pushed up in front of the roller. While the engineer in charge prescribes the amount and method of rolling necessary for a particular road material, there are a few basic rules in handling the roller to obtain the best results.

- On soft pliable materials, run the roller at slow speeds so that the material is not shoved or displaced.
- When rolling hot or tacky materials, be certain the water system is in working condition.
- Ensure the drum scrapers are properly adjusted.
- Do not make sharp fast turns. Steer the roller slowly so that the material is not marked or shoved out of place.
- Reverse the roller slowly and smoothly. One of the easiest ways of damaging an asphalt pavement during construction is to change direction of the movement too quickly.
- Do not leave the roller standing on the new road surface because the weight exerted by the drums may leave depressions in the pavement.

Even a relatively small roller can provide acceptable results if used properly. Know its limitations and capabilities before starting a project. Also, conduct a test patch with the material you will be getting and the roller you will be using. Have the engineer assistants do a density test as you are rolling the test strip so you can determine the best patterns, rolling times, and temperatures to use for that material. A little effort in the beginning will pay huge dividends in the finished product.

Pneumatic-tire rollers

Most pneumatic-tire rollers are self-propelled, although, some towed-type rollers are still around. Both do the same job. We use them when the soil to be compacted requires a kneading action to compact the soil.

13-wheeled roller

A 13-wheel roller generally has two tandem axles with six to seven wheels each (fig. 4–6). These wheels are arranged so they do not track one another, thus leaving no ruts. The body supported by the wheels is constructed so that it can be ballasted (add weight to) with sand or rock for additional weight. The weights may be varied to suit the material being compacted.

Note that the tires have no tread. When the roller is in motion on an unstable surface, the wheels have a kneading action and tend to rock from side to side. It is also used to make final passes over an area that has been first compacted by a sheepsfoot roller. Here, the surface is fairly stable, and the wheels run true.

The operation of a 13-wheel roller is very simple; it is merely towed over the area. Some towed pneumatic-tire rollers have fewer than 13 wheels, but the same principles apply when compacting soils. Not all rubber-tire rollers have the wobbling or kneading action, this will depend on the type of axle with which the roller is equipped. As with any other type of equipment, take care when selecting the type of roller you will need for your project.

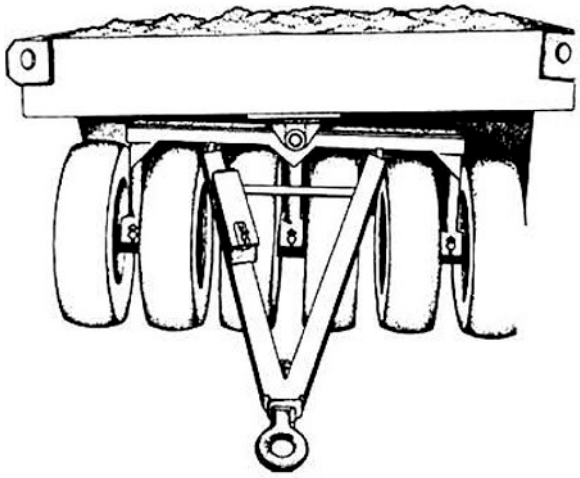


Figure 4–6. 13-wheel roller.

Self-propelled pneumatic-tire roller

The roller is a self-propelled pneumatic-tire roller that you operate on many construction projects (fig. 4–7). This roller is also a surface roller and is suitable for any type of soil. The self-propelled roller is constructed similar to the 13-wheel roller. The roller is mounted on two tandem axles with the smooth treaded tires arranged so the rear tires cover the spaces left by the front tires, leaving no ruts. One difference between the self-propelled roller and a 13-wheel towed roller is that it is fitted with scrapers for working in sticky soil and has a watering system for working with asphalt. The roller in figure 4–7 is a five-ton roller. When the machine is operated without ballast, its weight is approximately five tons. We can add ballast to increase the weight substantially. Check the owner's manual for specifics on adding ballast. We place the ballast in a compartment under or near the operator's seat and engine. We may place both sand and water in the ballast compartment. When filling the compartment with sand or water, place a water level across the rear of the machine to be sure it's level. If you are going to use water in cold climates, mix antifreeze with the water to prevent freezing and damage to the ballast compartment. If the roller is going to be stored over the winter, remember to drain and thoroughly dry the compartments to prevent damage.

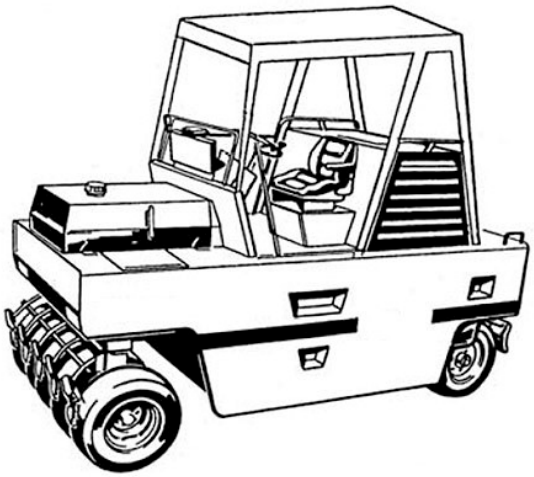


Figure 4–7. Self-propelled pneumatic-tire roller.

Operation of the pneumatic-tire roller

Before you begin compacting with the pneumatic-tire roller, make sure that all the tires have equal tire pressures. This ensures uniform compaction. As you roll, be sure each pass overlaps the preceding one by approximately one foot. This overlap eliminates uncompacted strips in the surface. Start the rolling operation on the outside of the project. If the area is on a grade, begin on the lowest side. This prevents displacement of the material under the weight of the roller. A pneumatic-tire roller can usually compact a four-inch layer of loose soil to 95 percent compaction, in two to four passes. Continue the operation until the surface is smooth and free from ruts left by the roller.

228. Industrial tractors

Industrial tractors are sturdy machines built with heavier and stronger front axles than those found on standard farm tractors. This allows the tractor to withstand greater pressure exerted by a front-end loader or other attachments.

The engine of an industrial tractor is usually in the 60-horsepower class and diesel powered. The engine powers the hydraulic system that gives the operator “fingertip” control of all mounted or attached equipment from the operator’s seat. The tractor is drivable for short distances at speeds of 15–20 mph. For long distances, it must be transported.

In the military, an industrial tractor is a piece of construction equipment used primarily for towing duties, light excavating, limited earthmoving, and sweeping. Industrial tractors can be outfitted with many attachments such as front-end loaders, front-mounted brooms, and mower decks. Industrial tractors work well for many different uses and complement our vehicle fleet. Also, individual manufacturers offer a wide variety of attachments that may or may not be interchangeable with other brands.

Mounting equipment

Several methods of mounting equipment on tractor assemblies have been devised. The most common and convenient method is the three-point hitch (fig. 4–8). It consists of two lower (outside) links and one upper (center) link. The lower links support the weight of the attachment, and apply the direct pulling power to it. The upper link provides a means by which the attachment can be positioned or leveled.

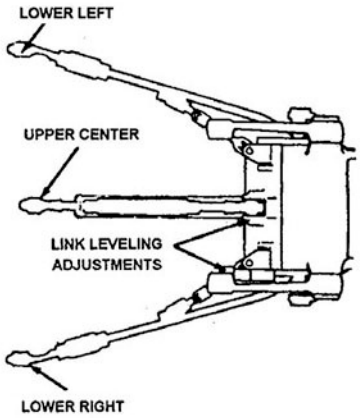


Figure 4–8. Three-point hitch.

The right lower link also has a leveling adjustment. By using both of these adjustments, you can level or position the attachment as needed. Once you position the attachment, you have complete control over it (e.g., raising, lowering, etc.) through the hydraulic system controls. Many attachments are pulled behind the tractor and are attached to a floating, swinging, or fixed drawbar.

Floating drawbar

A floating drawbar is a crossbar fastened to the lower links of a three-point hitch that can be adjusted (up or down) to match the height of the equipment hitch. This type of drawbar is ideal when you want to level the attachment you are towing.

Swinging drawbar

A swinging drawbar consists of a link hinged at the tractor end so that the opposite end is free to pivot across a supporting bar that is attached rigidly to the tractor housing. The swinging draw link is free to swing the entire width of the support bar or lock in place when desired. When pulling trailer-type equipment that does not require close positioning, steering is easier if the swinging drawbar is left free to swing. If the tractor has a three-point hitch, place the lower links in the UP position to prevent interference when the drawbar swings from side to side. When you want the pull on a load to be centered, bolt the draw link to the support bar in its CENTER position. Avoid overloading the drawbar.

Fixed drawbar

The fixed drawbar is found on many older model tractors; however, it can be used in many towing situations. It consists of a flat U-shaped draw link that is fixed rigidly to the tractor housing. Steel rod braces support the draw link and increase its load-carrying capabilities. The fixed drawbar has holes spaced along its length. On pin-type equipment tongues, you simply drop the pin through one of the holes. When a ball-type trailer hitch is used, mount the ball in one of the holes.

Power take-off

All industrial tractors have a hydraulic system powered by the engine. In tractors with a PTO, you must engage the pump before using hydraulically powered accessories. The pump is usually located at the rear end of the tractor housing and receives power directly from the tractor's clutch and transmission. Through a system of reduction gears, the PTO delivers power from the tractor engine to the mounted or attached equipment. Tractors with hydrostatic transmissions are essentially large hydraulic pumps themselves, so you do not need to "engage" a separate system to power accessories.

The PTO can be operated independently when the tractor is in any forward gear, reverse gear, or in neutral. In other words, if the forward motion of the tractor is stopped, the PTO continues to operate until it is disengaged. It operates independently of the tractor clutch and is controlled with a lever on the tractor frame.

Operating the PTO can be hazardous. Never engage the PTO when there is no PTO-driven equipment mounted to the tractor. *Always* disengage the PTO before you step down from the tractor. When you remove the equipment, remove the extension adapter, and cover the PTO shaft.

Attachments

The industrial tractor can perform many different jobs with the right piece of equipment attached to it. The tractor is worth very little to you by itself. It becomes a working unit when you equip it with one of several attachments.

Auger

When attached to the tractor's three-point hitch, the auger pivots on the support arms of the hitch. Because of this feature, you can drill straight down even if the tractor is headed uphill or downhill. You can also adjust the side tilt of the auger with the leveling arm on the three-point hitch before you start to dig if needed.

The PTO is what drives the earth auger shaft. Once ready to dig, engage the PTO, and lower the auger gradually into the ground until the hole is about one foot deep. Then raise the auger to remove the soil. Repeat until the hole is at the desired depth.

The type of auger we use to dig post holes is approximately nine inches in diameter; however, augers can range in diameters from 4–24 inches. Except for the smaller sizes, they have removable cutting

edges. The auger is attached to the drill shaft with a soft iron bolt, known as a shear pin, which will break if the auger jams. This shear pin prevents damage to other parts of the machine such as the PTO. If you need to replace a shear pin, use a replacement recommended by the manufacturer. *Never use hardened steel bolts*.

Front-end bucket

You can use a front-end loader bucket to backfill trenches, for light excavations, and to load materials into dump trucks (fig. 4–9).

Figure 4–9. Front-end bucket attachment.

The front-end loader bucket is powered by hydraulics and operates like a typical front-end loader. Its control panel usually has two levers: one to control the bucket tilt and the other to control the bucket lift. Since its lifting capacity and digging power are not as great as a loader, it is best used in soft or loose materials such as recently excavated earth. Its frame, hydraulic cylinders, and bucket are of a lighter construction than a typical front-end loader. Do not attempt to push as hard into a stockpile or windrow with this machine as you may cause considerable damage to the attachment. Always use lower gears to load or backfill.

Back-blade

You can use the back-blade in several different ways. The construction of the blade differs and affects the type of jobs for which it can be used. The most common type attaches to the standard three-point hitch. You can angle the blade to side-cast materials either left or right. Adjusting the leveling link of the three-point hitch also tilts the blade. We use the backblade for leveling, backfilling, light-clearing work.

Drag box

A drag box is attached to the tractor using the three-point hitch, just like the backblade attachment. The drag box has an open-bottom with two back-to-back cutting edges at the rear. A crossbar on the front of the box carries a set of scarifier teeth. These teeth can be fixed in position or raised hydraulically or manually when not needed. When operated in a forward direction, the scarifier teeth loosen the material while the front blade cuts and piles the material in the box. Then, the material can be dumped and spread by raising the box. When using the box in reverse, the rear blade cuts just like a dozer blade.

Front-mounted broom

The front-mounted broom gets power from the tractor through a series of hydraulic lines running from an engine-mounted hydraulic pump to the hydraulic motor(s) mounted on the broom itself (fig. 4–10). There is usually a control box mounted in the cab with which the operator can control broom speed, down pressure, and angle. These types of brooms are ideal for heavier debris that smaller brooms would have trouble removing. We will discuss the front-mounted broom later in the unit.

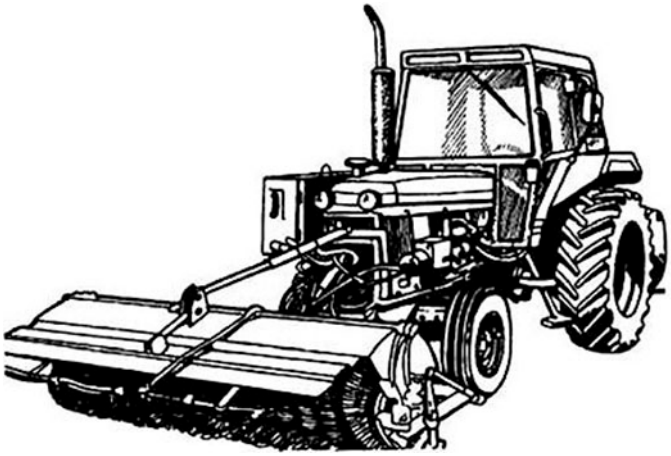


Figure 4–10. Front-mounted broom sweeper.

Mower

Tractor-mounted mower attachments, often called brush hogs, are powered by the tractor's PTO and are attached to the machine using the three-point hitch. Mower attachments can also be towed-type and can range from 4–20 feet wide. You use these mowers for cutting vegetation quickly in both improved and unimproved areas. Usually, these heavy-duty mowers chop up anything the tractor can go over. A tractor equipped with a 60-horsepower engine and a six-foot mower can normally cut brush up to one and one-half inches diameter (check the manufacturer's specifications before attempting). Depending on the mower, they may be able to cut materials that are up to three inches in diameter.

Use extreme caution when cutting in rocky areas, as rocks can damage and dull the blades. The mower also throws rocks a considerable distance, mainly to the rear of the machine. For this reason, always stop the machine when someone approaches.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

226. Water truck operations

1. What is the quickest way to reduce time when filling a water truck?

2. What are some of the disadvantages when filling the tank with a fire hose connected to a fire hydrant?

3. Why should you be careful driving the truck when the tank is not completely full?

4. What piece of safety equipment should you always wear when using the high-pressure hose?

5. How can the water pump lose its prime?

6. What can be done in shallow water to ensure enough water surrounds the suction end of the hose?

227. Compaction equipment

1. How do sheepsfoot rollers compact material?

2. What advantage is gained when working the sheepsfoot roller from the outside to the center of the road surface?

3. How does the steel-wheel roller compact material?

4. What keeps asphalt from sticking to the drum rolls on the steel-wheel roller?

5. Besides compacting and mixing clay soils, for what other purpose do we use the 13-wheel roller?

6. What do the self-propelled rubber tire roller and the towed 13-wheel roller have in common?

7. What is the purpose of overlapping each pass of a roller at least one foot?

228. Industrial tractors

1. What is the most modern and convenient method used to mount equipment on a tractor?

2. How can you make steering easier when pulling trailer-type equipment with the swinging drawbar?

3. What does the PTO do?

4. Briefly explain the procedures for drilling a hole with an auger attachment.

5. What are some uses of a backblade attachment?

4–2. Pavement Inspection and Sweeping

The AF has high standards of cleanliness. Base streets, parking areas, and airfields are all subject to these high standards. To maintain these high standards, airfield pavements and base streets must be swept regularly. Where does most of the litter on any base end up? It ends up on the street, against the curb, or can be found blowing across an airfield. Sweeping this litter up and keeping the streets and airfield clean improve the morale of the base personnel, help prevent illness, provides a favorable first impression for distinguished visitors, and prevents damage to aircraft. The airfield and all associated pavements are of prime importance. It's imperative that these areas are kept clean to prevent foreign object damage (FOD) to aircraft. FOD is a threat to many parts of an aircraft. Aircraft tires and jet engines are especially vulnerable to this threat. This threat is *not* to be taken lightly because its costs exceed millions of dollars a year. Each time an aircraft engine is damaged, hundreds of thousands of dollars are wasted. As a pavements and construction equipment operator, you play a key role in the prevention of FOD. To do your job successfully, there are some important items of information you need to know. In this unit, you will cover pavement inspection, the air sweeper, and front-mounted broom sweepers.

229. Pavement inspection

Each AF base is inspected daily for cleanliness. For the general base area, this includes streets, loading zones, and parking lots. Your job as a sweeper operator includes the daily inspection and sweeping (as required) of all pavement surfaces. For flight line and airfield areas, you'll work in coordination with base operations personnel. A key part of your job is to inspect the flight line and airfield for FOD. At some bases, it's required that the airfields be inspected several times a day. While not all the areas need to be swept, they must be inspected to ensure they are clean. Experience has shown that certain areas have a tendency to require more sweeping than others do. This valuable information can be obtained from base operations and from previous sweeper operators.

Responsibilities, safety, and inspection

At most bases, the responsibility for inspecting airfield pavements for foreign objects are placed upon the chief of airfield management. On a continuous basis, this individual has his or her officers and workers inspect the pavement. The BCE is responsible for sweeping airfields. The BCE passes the responsibility on to you, the sweeper operator. To do your job well, you must know how to inspect the pavements and keep them free from foreign objects. By knowing your responsibility and how to meet the challenges, you'll fulfill your part of the overall mission. In this lesson, we'll present some very important information you need to do your job safely and proficiently. The information is broken down into two segments as follows:

- Airfield safety procedures.
- Airfield pavement inspection procedures.

Airfield safety procedures

Before you operate any equipment on the flight line, you must first receive special flight line training at your base of assignment and have this annotated on an AF Form 483, Certificate of Competency. You must follow airfield safety procedures to the "letter." This is true whether you're inspecting the airfield or operating sweeping equipment. Violation of safety precautions can result in very serious consequences. *Don't take this warning lightly!*

The following are some of the more common things you must do when operating equipment on the airfield:

1. Before beginning operations on the flight line, check with base operations first. Let them know of your intentions and the area you'll be sweeping. They, in turn, will notify the tower that you'll be on the flight line.

2. Always obtain clearance from the control tower before commencing operations on or near the active runway or in any controlled movement area. Clearances are required when you move from one runway to another and when you depart from the area.
3. Whenever you operate on the flight line or not, keep in radio contact with the control tower. When you have a radio failure, make frequent visual checks with the control tower for warning and clearance light signals. The following are standard signals used throughout the AF, and you must be able to recognize them immediately:
   - Steady Green—Cleared to cross.
   - Steady Red—Stop.
   - Flashing Red—Clear active runway.
   - Flashing White—Return to starting point.
   - Red and Green—General warning—exercise extreme caution.
   - You'll learn more about these signals during your flight line training course.
4. Ensure your vehicle or equipment is in good working order. It must be properly serviced and equipped to complete the job.
5. Always use seatbelts and don't permit unauthorized persons to be in the cab or at the controls.

NOTE: Each base will be different as to specific procedures for flight line driving. Know the procedures, get certified, and stay aware.

Inspection of airfield pavements

Inspection of airfield pavements is a cooperative effort between you and the personnel of base operations. To give you an idea of how this cooperative effort works, the following steps cover how you and base operations personnel can work together to accomplish an inspection of an airfield pavement area:

1. Get a small map of the airfield and mark it each time you find an area that needs to be swept. After you've swept the priority areas, return to the other areas you marked on your map.
2. At the beginning of the day report to base operations for sweeping instructions. Afterwards, proceed to the priority areas that need to be swept first. As you begin your sweeping operation, continue to inspect the areas you're working in. Even though (from a glance) the area may seem to look clean, make a thorough check. This is done best by driving slow and moving back and forth across the area. One missed rock as small as one inch in diameter is large enough to damage a jet engine. If you find a large rock that the sweeper won't pick up, stop and pick it up, put the rock in the vehicle, and continue sweeping.
3. If while sweeping, you find several additional areas that need sweeping, mark them on your map. This will help you remember to go back and clean up those areas after you've completed your priority sweeping. One frequent trouble area is where a jet blast has blown debris onto a taxiway. Another area is where a small section of the pavement surface has failed leaving small rocks scattered around the taxiway. You should make a special note of failed areas so you can report them to your supervisor and base operations.
4. After finishing your sweeper duties, let your fellow sweeper operators know of areas that need to be concentrated on due to the high risk of FOD.

REMEMBER, there is no time for idleness or daydreaming while operating equipment in the airfield area. You must be alert at all times.

230. Air sweepers

Because it may be used on the flight line as well as on the base streets, the typical air sweeper you will likely use is shown in figure 4–11, and is considered to be a multipurpose machine. This multipurpose concept was developed many years ago; however, we are still benefiting from this technology today.

Figure 4–11. Air sweeper.

Traditionally, sweepers have used rotary brushes, brooms, and conveyors as the sweeping mechanism. Many manufacturers still use them as an effective method. In contrast, the sweeper pictured above is a regenerative air system machine. It uses air instead of the conventional rotary brushes, brooms, conveyors, and the various mechanisms required to house and drive them. Because it uses air, the air sweeper can clean surfaces at higher speeds and lower cost. In fact, the performance capability of this machine is limited only by the initiative of those responsible for its operation. Additionally, you may not operate any one specific model, but all models using a regenerative air system work essentially the same way. Check the manual for specific operating characteristics and adjustments of your machine.

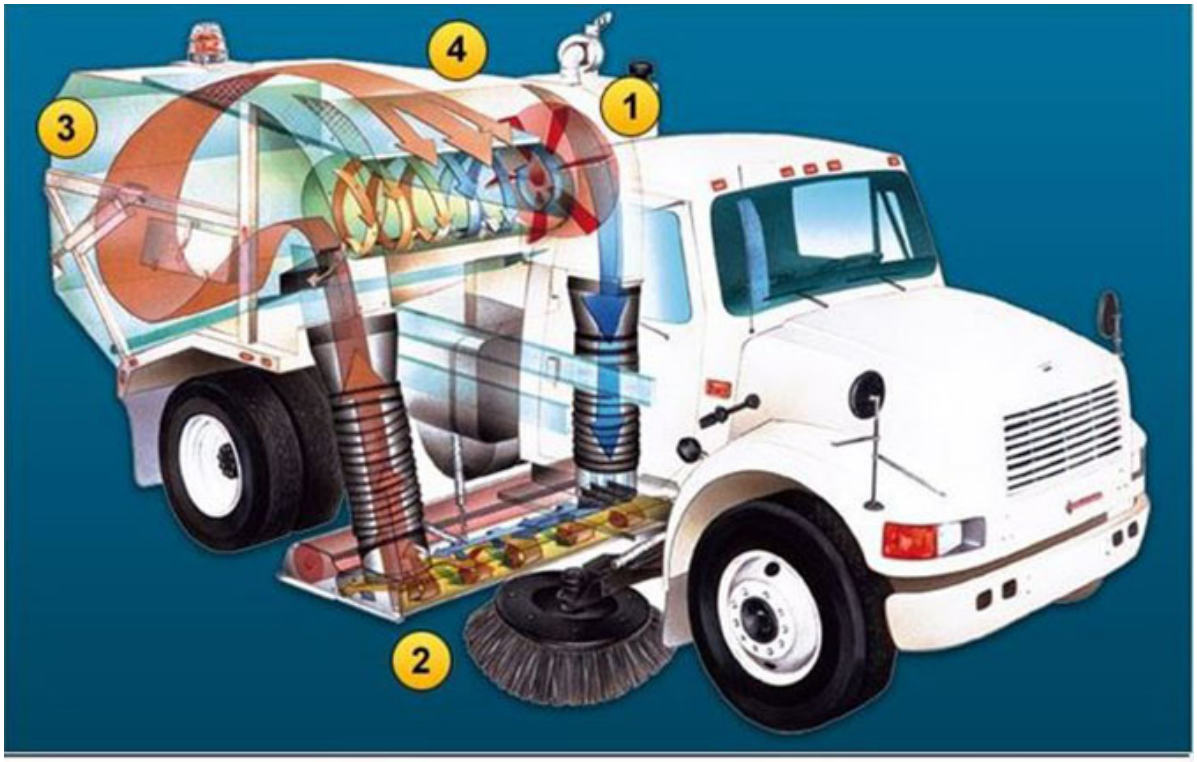
Because regenerative sweepers use an air system, there are times when aerodynamic problems will arise with it. These problems aren't easily identified and require a complete understanding of your machine; thus, training in the use of these sweepers is very important. In addition to aerodynamic problems, there are many different conditions found in sweeping operations. It's impossible to discuss all of them here. The most important factor in the operation of this machine is that it must be KEPT CLEAN. Now, let's look at sweeping characteristics and capabilities of the typical air sweeper.

Sweeping characteristics

Refer to figure 4–12 as we discuss the air sweeper. As mentioned earlier, the air sweeper is said to be a regenerative air system. It's simply a closed-loop machine in which the following events take place:

- A single blower draws air through the dust separator causing a vacuum throughout the hopper, suction hose, and suction inlet.
- Air from the blower is forced through the pressure hose and into and across the upper chamber of the pick-up head.
- A high velocity stream of air blasts forward and downward through a slot or "blast orifice" across the full width of the pick-up head striking the ground and picking up debris in its path.
- The debris-laden air then moves right in a spiraling motion toward the suction inlet. This powerful stream of air is contained beneath the pick-up head (fig. 4–13) by a skid plate at the end and flexible rubber curtains in the front and rear.

- As the air stream approaches the suction inlet, vacuum from the hopper combines with the high velocity air stream to lift debris through the suction hose and into the hopper.
- The air loses velocity as it enters the hopper and large debris falls to the hopper floor leaving only fine dust remaining in the air.
- The relatively clean air is drawn upward through a screen (eliminating paper, leaves, etc.) in the top of the hopper and into the dust separator inlet at the upper right of the hopper.
- The air stream enters the dust separator and begins spiraling towards the blower. As the air spins in the separator, centrifugal force throws the fine dust still in the air stream to the walls of the separator where it's skimmed off and returned to the hopper.
- The cleaned air continues to the blower and begins another cycle.



1. The closed-loop Regenerative Air System uses the force of a high velocity controlled jet of Air created by the powerful blower wheel.
2. This jet of air blasts down and across the pick-up head onto the pavement and into the cracks forcing up into the air stream packed-on heavy debris as well as fine dust particles.
3. The debris-laden air stream is pulled into the large hopper, where the air loses velocity and the larger debris falls to the bottom. A screen at the top of the hopper prevents items such as leaves, paper, cans, and rocks from leaving the hopper and entering the centrifugal dust separator.
4. The centrifugal dust separator spins the air along the curved wall of the chamber until the micron-size dust particles are skimmed off into the hopper. Only clean air is returned to the blower to start the Regenerative Air cycle again. This closed-loop system means no dirty air is exhausted into the environment only to settle on the surface again.

Figure 4–12. Regenerative air system.

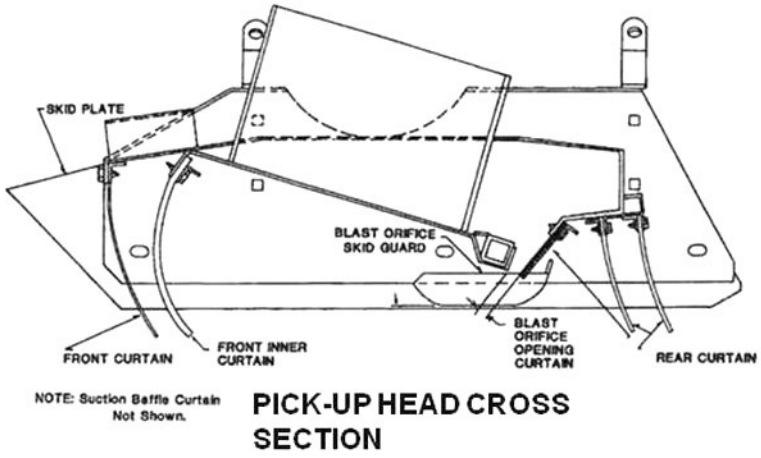


Figure 4–13. Typical sweeper pickup head.

Capabilities

The sweeper can be expected to clean normal debris that may accumulate on streets, parking lots, and other flat paved surfaces. Using the sweeper for more than what it was originally designed may cause excessive wear and failure to achieve the desired results.

Objects such as cans, bottles, glass, paper, leaves, and refuse or normal daily accumulation of debris are easily picked up by the sweeper. Keep in mind though, the air sweeper isn't intended, nor is it expected, to replace a shovel crew or a front-end loader. At times, an inspection at the dump site may reveal rocks and large objects in the hopper. This is due to air currents in the regenerative air system having the potential to pick up various large objects and retain them. A mixture of light debris will sometimes boost the large objects into the air stream and carry them into the hopper.

Because of the various types of sweeper pick up heads (high speed, standard, or broom assist) we can't say for sure at what blower RPM or truck speed you'll achieve your sweeper's full capabilities. Always check your owner's manual or applicable TO for the type of sweeper you are using. Both truck speed and auxiliary engine speed will vary depending on conditions. The sweeper can be operated at various speeds without changing blower RPM. Slower truck speeds are advisable for curb and gutter work where there is heavier than normal accumulations of debris. This prevents damage and wear to the pick-up head and gutter brooms. Higher blower RPM may be necessary under certain conditions; however with continual operation at excessive blower RPM, expect more wear because of the higher velocity of abrasive particles inside the sweeper.

231. Operating the air sweeper

In the previous lesson, we looked at the sweeping characteristics and capabilities of the air sweeper. Now, we're ready to look at the operation of the sweeper. We've broken this down into the following four areas:

- Preoperational checks.
- Operational procedures.
- Hand-held suction hose procedures.
- Dumping and wash down.

Preoperational checks

The first thing to do before operating any piece of equipment is to make a preoperational inspection. The regenerative air sweeper is no exception. In addition to the checks associated with the AF Form 1800, Operator's Inspection Guide and Trouble Report, you should check the hopper and inspection doors for a good seal. This inspection will ensure the closed system of the sweeper operates correctly.

Next, check all fluid levels of both engines and the hydraulics of the machine. Also, check the air cleaners for both engines. This is necessary because of the continuous dusty operating conditions. Make sure all lights are operating properly and you're almost ready to go. Your last preoperational check is to familiarize yourself with the controls, adjust your mirrors and seat, and buckle your seat belt.

Operational procedures

The following procedures should be adhered to when you're operating the air sweeper:

1. Start the truck engine; allow idle speed warm up.
2. Start auxiliary engine; allow idle speed warm up.
3. Check the truck and auxiliary engine gauges.
4. Turn on all safety flashers, beacons, and necessary lights.
5. While driving forward slowly, lower the pick-up head so it's flat on the pavement. Increase the auxiliary engine RPMs to the desired speed. Initial cleanup or heavy duty sweeping will require high RPMs.
6. Initial cleanup may result in stirring up more dust than you'd normally find in periodic maintenance sweeping. In addition, the air sweeper has the ability to rid the pores and voids in paved surfaces of the smallest dust particles. While the gutter broom is in operation or during unusually dusty conditions, you must use the hopper and pick-up the head water system, as well as the gutter broom nozzles. You should always use the water system unless you are operating in freezing temperatures.
7. To turn on the water system, engage the water system switch as required by the owner's manual or TO.
8. To use the gutter broom, engage the gutter broom switch to the down position. When properly adjusted, the tips of the gutter broom bristles will ride lightly over the surface resulting in a "flicking action."
9. Due to the possible speed of the air sweeper, special attention should be given to high-crowned streets with manhole covers and other heavy objects in the path of the sweeper that may damage the pick-up head.
10. Sweeping through standing water or over wet pavement won't damage the sweeper; however, be aware that the air sweeper has the ability to remove water from the surface rapidly, and thus, may require frequent dumping under such conditions if not fitted with a hopper drain.
11. When sweeping curbs, steering accuracy is quite necessary and damage can be avoided by slowing the sweeper down. Your speed will be determined by the amount of debris present and such obstacles as speed bumps, parking stops, and parked cars when sweeping clear and open areas.

Hand-held suction hose procedures

Referring back to figure 4–11, you can see the hand-held suction hose located on the back of the dump door. You can use this hose to vacuum areas the sweeper can't reach. You can also use the hose to clean around immovable objects and to clean up leaves in corners and other hard to reach places. The hose can be 15 feet long and six or eight inches in diameter. It's flexible and is easily moved and handled.

The following procedures are used when operating the hand-held suction hose:

1. Ensure pick-up head is on the ground and the auxiliary engine is OFF.
2. Install shutter plate between the suction transition seal and hopper inlet.
3. Go to rear of sweeper and unclamp the hand hose from the hangars and swing the hand hose assembly into place.
4. Start the auxiliary engine and set the engine RPMs as required by the owner's manual or TO.

5. Upon completion of sweeping, ensure the auxiliary engine is OFF before removing the shutter plate and disconnecting the hand hose.

WARNING: Never point the hand-held hose toward another person. If you do, serious injury may occur.

Dumping and wash down

When full, the air sweeper hopper may contain up to 6.0 cubic yards of debris. This presents no problem because the hydraulic dump system allows efficient dumping of the hopper. When you dump the hopper, its contents are deposited on the ground behind the rear axle. To do this properly, you should drive the sweeper to the landfill or a centralized dump location and follow this procedure:

1. Back up to the area for dumping. Use caution when backing and note any overhead clearance restrictions, deep holes, or objects that might damage the tires or the pick-up head.
2. Start the auxiliary engine and let idle.
3. At the outside operators station (located on the left side of the sweeper near the cab) actuate the dump switch. The hopper door will open and the raker-plate attached to the hopper door will drag debris from the hopper.
4. Close the hopper door. For best results and prolonged parts life, the sweeper should be washed and cleaned thoroughly.

The next set of steps describe the correct way to clean the sweeper:

1. Wash the hopper from the right and left side inspection doors first, with emphasis on the suction tube, the dust separator, and the hopper screen.
2. Open the hopper door and turn the engine OFF.
3. Open the separator door and clean thoroughly each day.
4. Leave the hopper door and all inspection doors in the fully OPEN position when the unit isn't in use so that the seals will dry and regain their shape.
5. Thoroughly clean the truck cab. Be sure to remove all objects that may interfere with brake pedals and accelerators.

NOTE: You must dispose of the debris in an approved dump area. Road debris is considered hazardous in most locations and must be handled correctly. DO NOT dump sweeper debris anywhere other than an approved site.

Operator adjustments on the air sweeper

Up to this point, you've learned about the sweeping characteristics, capabilities, and various operating procedures for the air sweeper. Now we'll cover the various adjustments needed to keep the sweeper operating at peak efficiency.

The pick-up head is the most important component of the air sweeper. Because this unit contacts the pavement, it can be damaged seriously by careless operation. Even when in transit with the head fully raised, the pick-up head is close to the pavement, thus, care must be taken. Before you raise the pick-up head, throttle the auxiliary engine down to idle and don't increase the engine RPM above idle before lowering the pick-up head. Certain types of pick-up heads cannot be operated in reverse and others can. Also, take care when sweeping over speed bumps. Most sweepers cannot operate over them, so pick the head up before carefully crossing them. Know your sweeper and its capabilities.

NOTE: We will present general information only. Always refer to the manufacturer's manual or TO for the proper procedures when making any kind of adjustments on the air sweeper.

An illustration of a typical pick-up head assembly is shown in figure 4–13. Many late model pick-up heads incorporate a bolt-on blast orifice opening curtain. Each time the pick-up head curtains are replaced, the blast orifice curtain should be set as required in the owner's manual or TO.

This action is completed by sliding the bolt-on blast orifice in or out. Failure to adjust the blast orifice curtain as required will result in poor sweeper performance. If the blast orifice opening needs to be adjusted, remove the pick-up head from under the sweeper. Turn the head upside-down, and bend the curtain clamp so the rubber curtain has the proper opening. Also, check for objects or blockage in the opening and clean as needed. In addition to the blast orifice, you'll also be concerned with two other adjustments as follows:

- Skid plate.
- Pick-up head spring.

Skid plate adjustment

The pick-up head is dragged on two skid plates (one on each side of the pick-up head). The skid plates are used to adjust the height of the blast orifice from the pavement. The skid plates should be adjusted to make contact with the ground, the full length of both sides of the pick-up head when sweeping is in progress. However, the skid plates should not bear the entire weight of the pick-up head as this would wear the skid plates out prematurely. A way to alleviate this premature wear is by adjusting the spring tension on the head.

Pick-up head spring adjustment

There are two main spring adjustments for the pick-up head (fig. 4–14, #1 and #2). Item one (1) shows the location of the front spring adjustment, while item two (2) identifies the rear spring adjustment. The purpose of these adjustments is designed to give the pick-up head a floating effect as it's dragged along the pavement. This serves the following two purposes:

- Prolongs the service life of the carbide skid plates.
- Forms a shock absorption system that helps to protect the pick-up head from sharp impacts.

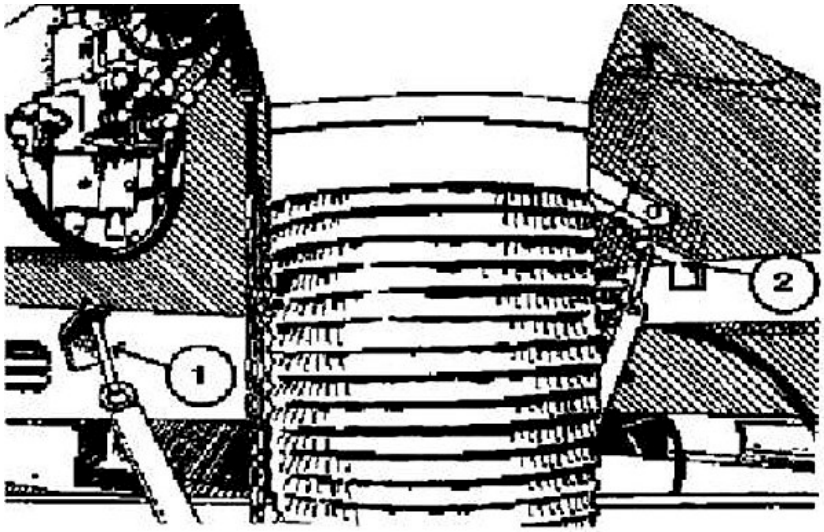


Figure 4–14. Pick-up head spring adjustment.

Once the spring tension is set according to the manufacturer's specifications, increase the sweeper engine speed according to the operator's manual required RPM and pull the sweeper forward. The increase in air velocity through the pick-up head should cause the pick-up head to draw itself down and seal to the pavement. Once drawn down, the pick-up head should then be easily lifted by one hand. This will demonstrate the floating characteristics desired. Remember, failure to keep the spring suspension system in proper adjustment will result in premature wear of the skid plates.

Gutter broom adjustments

The air sweeper uses a vertical digger design on the gutter brooms that enables them to remove heavy debris from the gutter and transfer it in front of the pick-up head. The gutter broom is also designed so it will fold under the cab if it runs into the curb or any other solid object. Always use care when the gutter broom is down. **Never** back up the sweeper with the gutter broom down; the broom could hang on a stationary object and break. In addition, you should **never** stand, step, or work on or near the gutter broom with it rotating. The gutter broom adjustments are shown in figure 4–15. The only adjustments you should be concerned with are the spring and tilt adjustments. When making your adjustments, park the sweeper on a smooth and level surface.

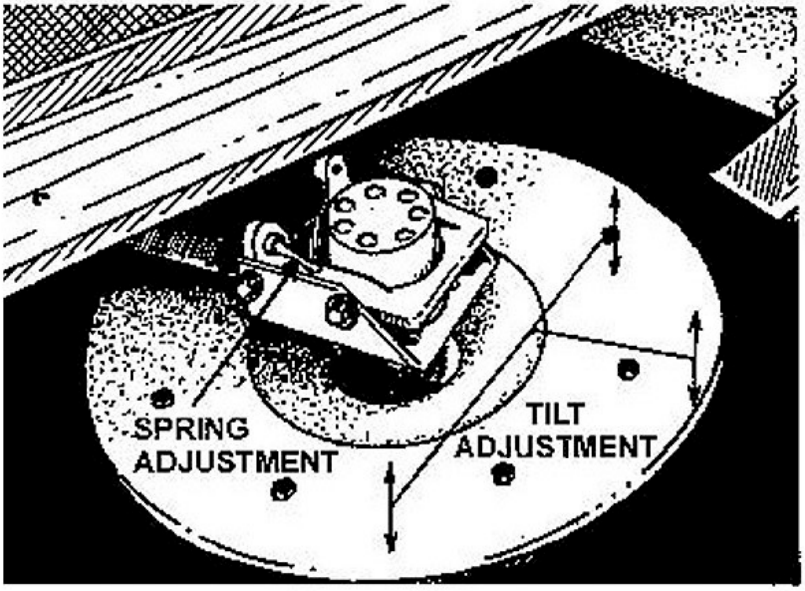


Figure 4–15. Gutter broom adjustments.

To adjust down pressure, put the gutter broom in the DOWN position. Once the broom is down, return the gutter broom control to the NEUTRAL position. With the auxiliary engine turned OFF and broom in the DOWN position, turn the auxiliary engine back to the ON position without starting the engine; the spring should be adjusted to hold the broom 1–2 inches off the ground, without the help of the hydraulics.

Adjusting the tilt of the gutter broom is done by moving the tilt up or down. Put the broom in the DOWN position. Once the broom is down, return the gutter broom control to the NEUTRAL position. Loosen the four bolts attaching the gutter broom to the bracket. Once the bolts are loosened, adjust the broom for the desired tilt by pushing down on the outside edge of the gutter broom. Once the desired tilt is achieved, retighten the four bolts.

Check the operator's manual for the correct broom pattern. This pattern should be one in which the broom's bristles reach into the gutter and pull debris out, distributing it under the front of the vehicle so the pick-up head can sweep it up. Too much down pressure and too much tilt (into the gutter) can cause premature wear.

Replace bristles when they are worn to within the recommended distance (usually 4–6 inches) of the base according to the owner's manual. Once they are worn that low, they lose their flexibility and "flicking" action which works best for sweeping.

232. Operating front-mounted broom sweepers

Front-mounted brooms can be used to sweep snow and other light debris from paved surfaces. In this lesson, you'll look at the operation of the front-mounted broom sweepers and the various material types you'll encounter.

Operation of the front-mounted broom sweeper

Front-mounted broom sweepers can be used to sweep snow and other light debris at speeds of up to six mph, depending upon conditions. The front-mounted broom sweeping unit is mounted on the front of an industrial or farm tractor (fig. 4–16). When used in this manner, it is intended to be used as a windrow sweeper. This means simply that the broom can sweep material either to the left or to the right, leaving a windrow of material as it passes.

Safety

When sweeping with the front-mounted broom sweeper unit, always keep safety in mind. As a minimum, you should adhere to the following precautions:

- Be sure you wear the proper protective equipment, such as goggles or face shields if your tractor does not have an enclosed cab. These are very important because dust and debris can be blown back into your face depending on the wind direction.
- Keep your hands, feet, and clothing away from all moving parts.
- Never sweep toward people, buildings, vehicles, or other objects that may be damaged by flying debris.

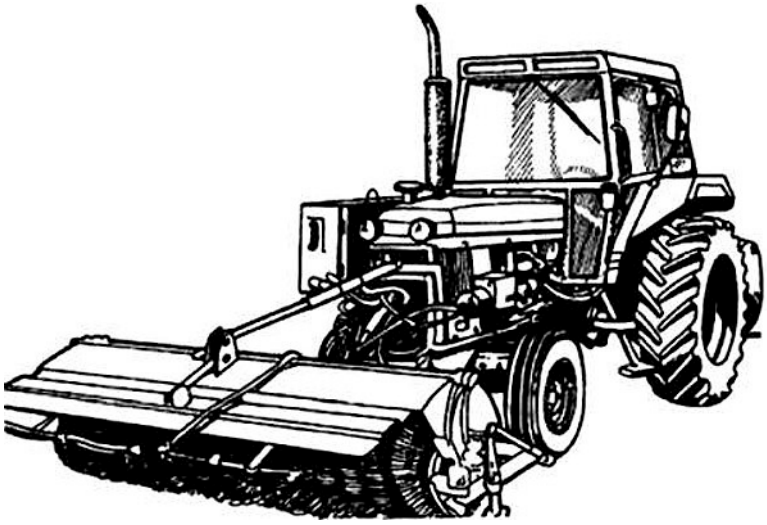


Figure 4–16. Front-mounted broom sweeper.

Operation

The sweeping unit is driven by a two-speed hydraulic motor mounted on the end of the core. For ease of operation, all broom functions are controlled inside the cab from a panel located to the operator's right. Basically, you'll be involved in two types of sweeping operations: (1) dirt and gravel and (2) snow.

Dirt and gravel

By using a low brush speed along with a moderate ground speed, you can sweep and clean almost any hard surface of debris. If brush speeds are too high, dust will be raised by the sweeper. Use just enough brush speed to roll the gravel rather than throwing it into the air. Remember the sweeping unit isn't a bulldozer. Don't ram the unit into piles or try to move them as you would with a blade.

Snow

High brush speeds and low ground speeds are a better combination to efficiently remove snow. Start out using three-quarters throttle and the tractor in the lowest gear. In deep or wet snow, increase the throttle to near full. This will help prevent the snow from packing inside the broom hood. Always keep the wind direction in mind during snow removal operations. In deep snow, subsequent passes may be needed to achieve to bare pavement conditions.

Broom adjustments

The life of the broom is related directly to the way it's used. The following are three factors that you can control to give longer brush life:

- Brush down pressure.
- Keeping the broom level.
- Ground speed.

Down pressure

Putting more down pressure on the broom doesn't mean you'll get a better sweeping action. The reason for this is that the broom gets its sweeping action by the flicking action of the bristles; sweeping is done most effectively with the tips of the bristles. When too much pressure is used, the broom is working with the sides of the bristles and not just the tips. This action, known as *mopping*, will not only decrease the efficiency of the broom but will also cause one-half to one and one-half inches of bristle to be worn off at one given time.

The sweeper is equipped with adjustable spring assemblies to limit the down pressure. To check for the correct down pressure, rotate the broom at normal operating speed with the machine stationary. When the broom is lifted, it should leave a two- to four-inch cleared pattern.

Leveling the broom

To reduce uneven broom wear, the broom level should be checked every day before operating. Uneven broom wear can be caused by discharging material to the same side of the broom all the time. You can alleviate this by flipping the broom core end-over-end a couple of times during the course of its life.

Ground speed

Improper ground speed will not only damage the broom but also the core, sprockets, drive lines, and frame. Since the broom drifts material ahead of itself, it can sweep material up to one-half the diameter of the broom. When the ground speed of the tractor is too fast, the material will pile up in front of the broom. This happens because the dirt can't be discharged. This will cause a plow effect from bulldozing with the sweeper. In turn, this will cause a side thrust on the broom, core, and frame. The side thrust can cause the broom bristles to flex against the steel ring holding them. Eventually, this flexing will cause the bristles to be broken off at the ring.

You should always sweep at a high enough broom speed and low enough ground speed to discharge the material being swept effectively. Watch the material as it leaves the broom and periodically check behind you. If there is material left behind, you may want to adjust your speed accordingly (slow down). Additionally, if the material is being swept well, you may be able to speed up slightly. Constantly monitoring your sweeper's effectiveness will make the operation much more successful.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

229. Pavement inspection

1. Who ultimately has the responsibility for sweeping airfield pavements?

2. What must happen before you are allowed to operate any equipment on the flightline?

3. What should you do if you are sweeping on an active runway and your radio fails?

4. Before beginning any sweeping operation, with whom do you report to before beginning your airfield inspection?

230. Air sweepers

1. What is the most important factor in maintaining the air sweeper?

2. What is forced through the blast orifice creating a spiraling motion across the pick-up head?

3. How is fine dust taken out to the airflow in the regenerative system?

4. Slower truck speeds are advisable for what type work?

231. Operating the air sweeper

1. In addition to the items listed on the 1800, what items should you check during the preoperational inspection?

2. Why is it important to check the air cleaners on both of the engines?

3. What approximate speed should you use when you are sweeping curbs?

4. What can the hand-held suction hose be used for?

5. After dumping and cleaning, why should the doors of the sweeping unit be left open?

6. What will happen if the blast orifice curtain is not set as required by the manufacturer's manual or TO?

7. How can you prevent premature wear of the skid plates?

8. Why should you never back the sweeper up with the gutter broom down?

9. What two adjustments on the gutter broom should the operator be concerned with?

232. Operating front-mounted broom sweepers

1. Where are the front-mounted broom operating controls located?

2. If you are sweeping heavy snow, how much engine throttle should be used? Why?

3. What causes mopping?

4. How do you determine the correct speed to discharge the material being swept effectively?

4–3. Asphalt Paving Machines

In this lesson, we will concentrate on the asphalt paving machine. Asphalt pavers come in many sizes and configurations and make paving an asphalt surface fast and efficient. We will highlight some of the features of these essential pieces of equipment, and then we will discuss how to properly operate one.

233. Types and features of asphalt paving machines

There are two basic types of paving machines: towed and self-propelled. Features and accessories vary greatly among manufacturers, but they are essentially the same in that they spread an even mat of asphalt by way of a screed.

Towed

For small paving jobs where the lane you are paving is usually no more than eight feet wide, it is sometimes easier to use a towed-type paver. In some units, this may be the only paver available. Towed pavers are connected to the rear of a dump truck through locking arms which lock into the wheel hubs. Material is dumped from the bed of the truck directly into the hopper of the paver. The material then falls directly to the base. As you move the truck forward, the material is struck off by a blade, a cutter bar, or a screed. The screed maintains the asphalt mat at a specific depth throughout the process.

Some towed-type spreaders have floating screeds which can be adjusted for different depths. Simply rotate the adjustment gauge in either direction to raise or lower the height of the screed. If your spreader does have a screed, it is always good practice to check the trueness prior to conducting any paving operations. If you are operating the dump truck, always tow the spreader at a uniform speed for any given setting. If your towing speed varies, the spread may vary in thickness as well. With careful set up and operation, you can achieve good results.

Self-propelled

Self-propelled pavers have either crawler tracks or wheels and rollers that run on the base or surface to be paved. They literally push the dump truck supplying the material ahead until it is empty. They can vary in size from small four- to eight-foot screed widths, all the way up to 16-foot adjustable screed widths with an integrated adjustable crown. These units typically come as wheeled or tracked (figs. 4–17 and 4–18). The tracked paving machines are superior in that they do less damage to the base than their wheeled counterparts because they don't spin. A wheeled paver has a tendency to spin its tires when the hopper is full, as they are trying to push a loaded dump truck; however, maneuvering a tracked paving machine can be challenging and it can disturb the base when turning sharply.

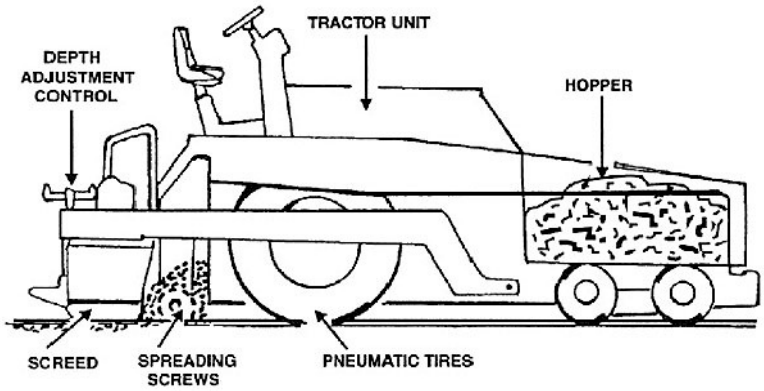


Figure 4–17. Wheeled paver.

The hot mix from the central plant is dumped directly into a hopper at the front of the machine. The spreader or paver places the mix evenly on the road behind it through a series of conveyors and a heated screed. The wheeled paver and tracked paver can handle any type of asphalt mix, cold or hot, but hot mix is what they were designed for.

When operating the dump truck supporting the paver, keep your feet off the brakes and let the paver do the work. Riding the brakes only makes it more difficult for the paver operator to lay a uniform mat due to irregularities in forward movement. It also puts undue stress on the paver. Additionally, do not keep the transmission in gear and try and "help" the paver by driving forward. This will inevitably lead to spillage in front of the machine which will have to be removed before moving on as the paver may ride up onto the pile, disrupting the mat.

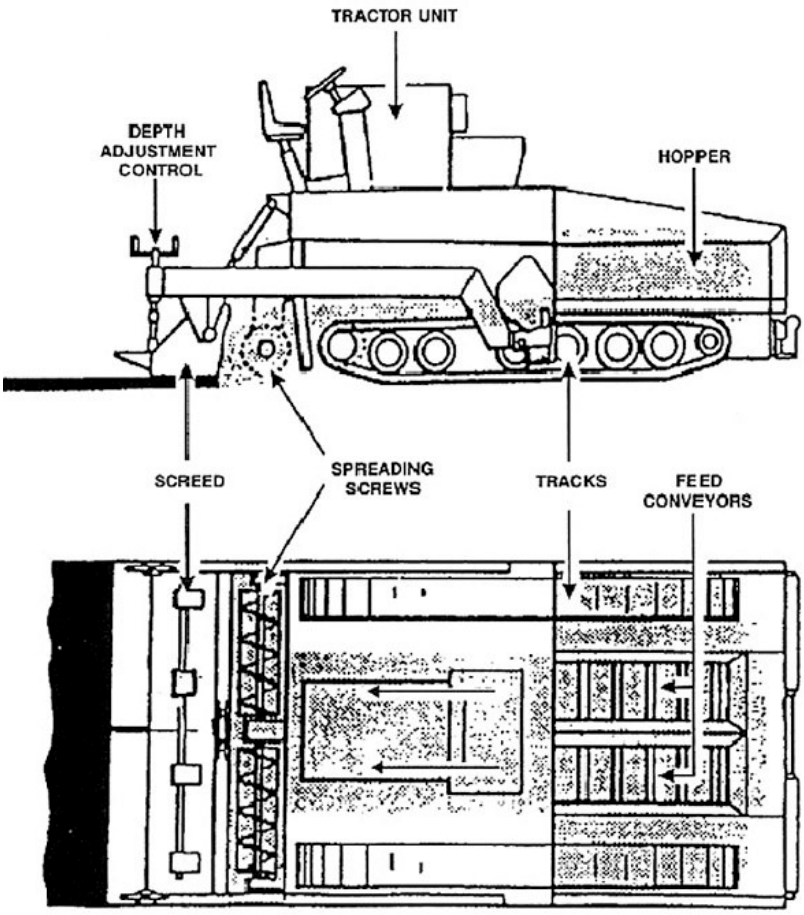


Figure 4–18. Tracked paver.

Typical components

There are some typical components found on every paving machine, but we will be concentrating on the self-propelled paver because this is the type you will use most often.

Hopper

The hopper is where the dump truck dumps and holds the hot asphalt. Its shape allows material to funnel down into the bottom and into the conveyors before being distributed to the screed. Some pavers have hydraulically operated sides which can be raised and lowered to make the asphalt fall to the bottom of the hopper.

Conveyor

The conveyor simply transports the material to the rear of the machine. Without a conveyor, the hopper would literally have to sit on top of the screed to feed it.

Operator's station

The operator's station is where you operate the paver. You have control of the machines vital systems like the hopper, the screed burners, engine, transmission, and steering controls. Additionally, some models have either two operator stations (one on each side) or a movable station that can slide from one side of the machine to the other. This enables the operator to see centerline marks and other reference points while paving.

Screed control stations

Most paving machines have separate screed control stations located at each side of the screed. They control such things as the elevation, the width, and the augers. The augers bring material from the center of the machine and distribute it evenly across the width of the screed.

Screed

The screed is the most important component of the paving machine. It does more than just level the material, it also regulates the mat depth, it shapes the mat and it even compacts the mat as it is laid. Initial mat compaction from the screed can be as much as 85 percent due to vibrators (if equipped); therefore, you need to have it adjusted and working properly. The screed can be adjusted for width by extending or retracting the "wings" on each side. It can also be adjusted for positive (a crown) or negative slope (a depression for drainage).

234. Paving operations

The very first thing to do before paving commences is to develop a checklist for inspecting the machine. A checklist for the paver should include things specific to your paver. The reason we do this is because the AF Form 1800 is vague and inadequate. Additionally, a checklist should be used when conducting a post-operational inspection so items of importance are checked before parking it for the day.

Setting up the paver

Once the machine has been thoroughly checked out and is on-site, you must ensure the screed and automatic grade control devices are set up properly. Automatic grade control devices typically use sonar to maintain a standard operating depth across the width of the screed or can be adjusted for slope. If you have a fully automated screed, you can simply adjust it until it is zeroed out (perfectly level). Go back and check it to make sure by running a taut stringline across the plates and see if there are any variations. Also, check the plates to make sure they are aligned and there are no gaps or raised edges. You want the screed to be as smooth and true as possible.

Once you are satisfied with the screed's trueness, fire the burners and let the screed heat up. You heat the screed so that the material will pass smoothly under it, making a smooth, void-free surface to the mat. If you don't heat the screed, the material may cool slightly and drag across the screed causing material to stick to the screed or surface irregularities that may not go away after rolling. Heat the screed for the recommended period of time.

While the screed heats up, maneuver the machine to the start point, usually a prepared edge of existing asphalt. Back the machine in line with the lane until the screed is over the existing area by approximately a foot and stop. Slide pieces of wood or a sheet of plywood up under the screed as a spacer to hold it up at a predetermined elevation. We do this to account for the compaction of the material. Previously, we learned that we should conduct a test patch for compaction with the material we will be using. During that test, we would also test how much the material compacts and how much overfill we would need. For instance, our test patch may reveal the asphalt compacted 3/4 of an inch; therefore, our wood that we put under the screed would have to equal 3/4 of an inch.

Finally, set the screed onto the spacers, but don't put the full weight of the machine down. Lift it slightly so it doesn't dip down when you start out, due to the weight of the screed pushing down. Go through a systems check and make sure everything is functioning correctly and ready to go. Move the hopper up and down a few times, check the conveyors and augers to make sure they are functioning

and make sure the engine is running properly and it is able to throttle up and idle down normally. If anything is amiss, get it fixed immediately so hot asphalt isn't waiting on the paver.

Operating the paver

A ground guide should direct trucks into the paver and spot them as they dump. The trucks should never try and dump the entire load if the hopper can't accept it. Dump enough to fill the hopper without spilling any. Once the operator feels there is enough material in the hopper, he turns on the conveyors and starts bringing the material to the back of the machine. Once at the back of the machine, the screed operator turns on the augers and distributes the material across the screed until all the voids are filled. Only then can the paver move forward and start paving.

At this point, the screed burners can be turned OFF (if they are not temperature controlled) because the heat of the material will keep the screed hot. The paver operator pulls forward slowly and smoothly, making sure not to jerk or stop suddenly. The screed operator will watch as the screed moves forward off the spacers to make sure it doesn't dip down. If the screed was set up correctly, it will provide a smooth transition to the mat.

As the paver moves forward, the screed operator will constantly check the depth of the mat with a depth gauge and adjust the screed as necessary. He will also ensure the mat is restricted to the confines of the centerline and edge markings by extending or retracting the screed extensions. If the mat is going down smoothly and the depth is consistent, we simply monitor progress. Don't make adjustments just for the sake of doing something. Making too many adjustments can lead to an inferior surface. Also, don't adjust too much at one time. For instance, if you need to raise the screed because your depth is off, don't try and raise the screed the entire amount at one time. Raise it a little at a time and check the depth often. If you move it too much, then you have to go in the other direction and before you know it, you have a roller coaster.

If you are using the automatic grade control devices with your paver, your job becomes much easier. Typically grade control devices are used when constructing pavements of two or more lanes. If just two lanes are being paved, one end of the screed will be fitted with a sensing device for grade (depth) control, while the other end is typically fitted with a slope-control mechanism to allow for a crown in the center of the two lanes; however, if paving more than two lanes, a slope-control device is not required. For more than two lanes, grade control devices are used on both ends of the screed.

NOTE: A pavement will only be as level as the base in which it is being laid upon. If a parking lot requires slope for drainage, be sure that the base is prepped for it so the asphalt can maintain a standard thickness throughout the project. This practice doesn't just apply to parking lots but to all paving projects.

If there are no trucks available and the hopper is empty, stop the machine. If you are waiting for an extended period of time, you can let the burners warm the screed. This will also help keep the material under the screed warm. If you are stopping for the day, simply pull the paver forward until the material runs completely out of the machine. You will have to come back later and cut the asphalt to establish a straight edge to work from the following day.

Clean up

Cleaning a paving machine can be a tedious task, but it is absolutely necessary. Asphalt left to set up can be almost impossible to remove. If you clean it off as soon as possible after paving has stopped (like at the job site), it is much easier. Use an asphalt release agent or heat to soften the asphalt. Never use diesel fuel as it will inevitably end up on the ground. Diesel also breaks down asphalt which could affect the next batch going through the machine.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

233. Types and features of asphalt paving machines

1. What are the two types of pavers?

2. What do wheeled pavers have a tendency to do that tracked pavers do not?

3. What are the five components of self-propelled pavers?

234. Paving operations

1. Why do you let the burners heat up the screed?

2. Why do we set spacers under the screed when starting paver operations?

3. What can happen if you try and adjust the screed too much at one time?

4. What can be used to help clean the paver?

4–4. Snow Removal

Snow removal on a typical base includes airfields, streets, parking lots, and other paved areas. Each area presents its own set of peculiar problems. In this section, we'll look at three areas that are "key" to an effective snow removal program. First we'll discuss the equipment used for snow removal. We'll then look at the operating techniques used for flight line snow removal. We'll conclude the section with a discussion of how to clear snow from lights and aircraft arresting systems (AAS).

235. Snow removal equipment

Snow removal equipment comes in variations of shapes, sizes, and types. The equipment can range from common push plows, sometimes called displacement plows, to sophisticated rotary-type equipment. In this section, we'll look at the types you'll usually use in your job. These include blower and plow-type snow removal equipment and front-mounted snow brooms.

As an operator, you'll be operating various types of snow removal equipment. If you are to be successful, you must learn to operate the following snow removal equipment and their systems safely and effectively:

- High-speed ribbon blower.
- Multipurpose snow removal unit (MSRU).
- Displacement (push-type) plows.
- Construction equipment.
- Regeneration systems

High-speed ribbon blower

The high-speed ribbon blower is designed to use multiple ribbons that feed snow into the impellers (fig. 4–19). An auxiliary engine transmits power to the blower assembly through a drive shaft. As this drive shaft spins, it turns the impeller and discharges the snow through a maneuverable chute or by discharging out the side of the blower head.

Figure 4–19. High-speed ribbon blower.

Because the rotating parts of the blower assembly are heavy, you should slowly engage the clutch. If you engage the clutch too quickly, you'll weaken or break the shear pin installed in the drive shaft.

NOTE: The shear pin is a built-in weak point. It's a safety device used to prevent damage to the drive shaft, blower assembly, or other parts of the blower. You should always carry extra shear pins while operating. Be sure to use shear pins that meet requirements as specified by the manufacturer only.

Once the clutch is engaged, you can increase the RPMs to the governed speed. Some of the newer high-speed ribbon blower models are driven by hydraulic motors that have high-pressure relief valves that disengage to prevent damage to the mechanical systems.

Multipurpose snow removal unit

The MSRUs are versatile all-wheel-drive vehicles. They're equipped with a quick-connect mounting system enabling you to choose between a blower, displacement plow, or front mount sweeper (figs. 4–20 and 4–21).

Figure 4–20. Multipurpose snow removal unit (blower).

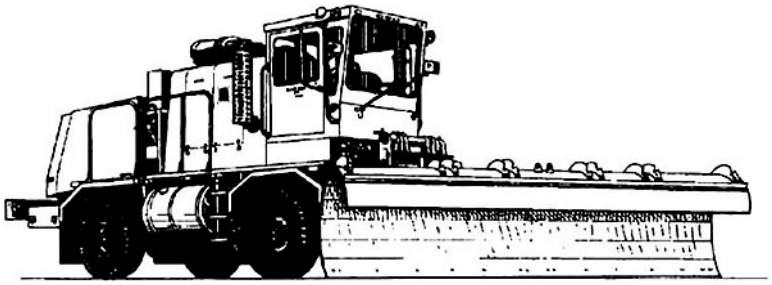


Figure 4–21. Multipurpose snow removal unit (plow).

The multipurpose blower units come in these two classes; 2,000 tons per hour (TPH) unit and 3,000 TPH. The 2,000 TPH unit blower assemblies are equipped with a 300 horsepower engine capable of handling 2,000 TPH of snow. It can discharge the snow up to a distance of 130 feet. The 3,000 TPH unit blower is equipped with a 330 horsepower engine capable of handling 3,000 TPH of snow by discharging it a distance of 150 feet.

The snow blower configuration is designed to remove snow that's too deep to be plowed or that has been plowed into windrows. The discharge chute on the top, above the impellers, is for directing the flow of snow. This chute can be rotated to blow the snow to the right or left. The blower can also be extended to control the angle and distance the snow is blown. If you adjust the chute properly, snow can be loaded into trucks with the blower.

Options

An optional rear wheel steering configuration is available on the 2,000 TPH unit. This greatly improves maneuverability when you're working around airfield lights, runway markers, and turning around on taxiways, and runways. In addition, you can activate an all-wheel-steering provision by using an electronic selector switch inside the operator's cab. The electronic selector allows you to select front wheel steering only, crab steering for moving sideways, or both front and rear steering for tight turns when available. By using this steering option, the turning radius is approximately 40 percent less than a truck with only front wheel steering.

Another option is a loading chute that can be installed on the blower head of the 2,000 & 3,000 TPH units. This chute enables the blower unit to load trucks from windrows where the snow can't be blown or where it must be hauled away. The chute also allows the operator to blow the snow directly ahead when working in confined areas.

You can mount the prime mover with a 16-foot reversible plow, or quickly interchange and mount it with an 11-foot multisection plow. Additional, plows are available to attach to the prime mover whenever snow and ice removal procedures are in operation and where all assigned snow blowers aren't required.

Operation

Blowers are operated by throttling the auxiliary engine to full governor speed and adjusting the truck speed, so that the blower operates at full capacity. A light discharge will result when the speed is too slow. When the truck speed is just right, the snow is compressed by the impeller and the discharge pulsates. A good way to tell when you're operating to capacity is by the sound of the auxiliary engine. It should run with a good even roar, not lugging, but with the governor letting it work.

Cautions

You should exercise great care if you're operating a snow blower on base streets or parking areas—especially with the chute engaged. For flight line areas, several items present hazards. Aircraft chocks, rocks, and ice chunks are three hazards that often break shear pins or cause major damage to snow blowers. In addition, portable ground equipment can become a problem. If this equipment becomes covered with snow, it may be picked up and jammed into the blower impellers, shear the pin, and damage the blower. The logical way of prevention is to have this equipment moved before snowstorms arrive.

Displacement plows

Displacement (push-type) plows are most common in snow removal operations. The following are two types of plows most common in snow removal operations:

- Reversible plow.
- Rollover plow.

We'll look at the characteristics of each type and see how they're used. In addition, we'll discuss how to change the cutting edges and shoes on push-type plows.

Reversible plow

The reversible plow can be mounted on dump trucks, MSRUs, and other prime movers (trucks) (fig. 4–22). It can be positioned to plow snow straight ahead, angled to throw snow to the right, or angled to throw snow to the left.

Figure 4–22. Reversible plow.

Reversible plows are most efficient for cleanup work or for use in restricted areas where you desire to change the angle of the blade rather than to deadhead (plow straight ahead). These plows are also good for removing light snow from roads, walks, platforms, and storage areas.

They can be used to plow airfield pavements, although they move less snow than the 54,000 pound rollover snow plow. We will look at it next.

Rollover plow

An example of a rollover plow is shown on figure 4–23. The name is in reference to the blade itself, not the vehicle so your unit may have different prime movers, but the blade doing all the work will be similar. This type plow can plow snow to either side. The cone-shaped plow gives snow a lifting, rolling action, and throws snow a considerable distance at speeds up to 55 mph. To roll the cone-shaped plow from right to left, raise the plow as high as it will go and (as the name applies) roll it over. When you do this, the toe will remain at the bottom of the arc, and the heel will be the top of the arc. There's only a few inches of clearance when the plow passes center; therefore, to prevent damage to the plow, don't rotate it with the plow traveling at high speeds. After you roll the plow over and you begin another pass, return the plow hoist lever to the FLOAT position to allow the plow to follow the contour of the pavement.

Figure 4–23. Rollover plow.

Whenever possible, you should operate a rollover snow plow at a speed of at least 30 mph. At this speed, you'll get good rolling action off the end of the blade. If you drop the speed to less than 20 mph, the snow won't have any casting distance when it comes off the end of the plow, and it will form a windrow. If the intent was to build a windrow for blowers to remove later, then the rollover blade is ideal for building sizable windrows. On the other hand, if you maintain a speed at least 30 mph, the snow will be thrown off the high end of the plow and be scattered thinly. When plowing windrows with a rollover plow, you can keep your speed up by taking less than a full blade of snow or by drifting out of the windrow until you regain your speed and then pulling back into the windrow.

Changing cutting edges and shoes

The cutting edge on a plow is called the blade, and the blade base is called the moldboard. The shoes support the weight of the plow and blower head and ride between the ground and moldboard. Without the shoes, the blade would literally wear down into the moldboard quickly due to the weight of the blade assembly. The blade is bolted to the moldboard, the bottom part of the snow plow. Plows often differ when it comes to the number of cutting edges bolted to the moldboard; however, most are bolted onto the moldboard the same way. The cutting edge and shoes are considered wearing surfaces and may easily be worn into the moldboard if they aren't frequently replaced.

Changing cutting edges and shoes is part of operator maintenance. When you're changing cutting edges or shoes, always keep safety in mind. Never, under any circumstances, change the cutting edges or shoes with the engine running. Always block the plow or blower head up—don't take any chances. After blocking, remove the bolts from the blade or shoes. You may be able to reverse cutting edges if

they are double-sided. You may need to use a large punch to align the bolt holes when putting the new blades on. The best policy when you change cutting or wearing edges is to use the proper tools.

Construction equipment

Other equipment such as bulldozers, graders, and front-end loaders are valuable in snow removal operations. The operating procedures don't differ much from any other operations for which you may use this equipment. If you can operate these efficiently in other operations, you won't have any problems during snow removal.

Operating techniques for front-mounted snow brooms

Snow brooms are also used in the snow removal operation. Timely use of the snow brooms can save many hours of work for the plows. In this lesson, we'll discuss the main type of snow brooms used for snow removal in today's AF.

Front-mounted snow brooms are attached to a prime mover, normally a MSRU or 5- to 10-ton dump trucks, and are powered by a gas or diesel engine mounted in the bed of the truck (fig. 4–24). The brooms are hydraulically controlled which allows for smooth operation. Front-mounted brooms are capable of sweeping wet slush, heavy snow, dry snow, and may also be used for sweeping debris in warmer temperatures. The brooms also come equipped with a high velocity blower mounted (air-blast) to the rear of the prime mover. When the broom is angled, the blower nozzle automatically changes the direction of its blast at 180 degrees to the sweeping direction. This allows the air-blast nozzles to blow across the swept path towards the unswept area. The air-blast can move dry light snow several feet, helping decrease the snow load on the broom in subsequent passes.

Figure 4–24. Front-mounted snow broom.

Advantages

There are several advantages to the front-mounted sweeper. One of the major advantages this type of sweeper has over a towed model is that with the broom mounted in front, it can sweep the area before the sweeper caster wheels or truck tires pack the snow. In addition, the operator has a clear vision of the area to be swept, and a faster forward speed is achieved. Another distinct advantage is that the controls for both the broom and air-blast system are mounted inside the vehicle cab allowing easy control for the operator.

Disadvantage

There is one disadvantage of the front-mounted broom on a dump truck. The diesel engine mounted in the bed of the dump truck ties up a truck that may otherwise be used for hauling snow.

Operating procedure

The operating procedures for the front-mounted snow broom won't differ greatly from procedures for the towed broom that we discussed previously.

Broom adjustment

The front-mounted broom core on both MSRU and front-mounted dump trucks are self-leveling to assure longer bristle life and even wear. The self-leveling feature gives the brush the freedom of upward and downward movement to follow any irregularities of the runway. In addition, brush suspension allows movement up and down and permits one end of the brush to follow contours, thus, keeping the brush level without excessive brush wear.

The broom frame is equipped with a single bolt adjustment that allows you to set the correct brush pattern quickly. Set the brush pattern at the width of five inches the entire length of the broom. Change the bristles when they wear to within eight inches of the outer diameter of the broom core.

The front-mounted tractor brooms discussed earlier are used for removing light snow. They can also be used for cleaning up after plows, especially on walks, platforms, ramps, intersections, and around obstructions, such as contact lights and flush-type outlets. Use caution when using the front-mount broom on hard packed snow or ice. If you don't, the broom may actually glaze or polish the ice and reduce traction. When sweeping ice, steel bristles are best for cutting ice, whereas, poly bristles (plastic) are best for flipping snow

Regeneration systems

Diesel engines produce a variety of particulates during the combustion process which powers the engine. These particulates vary widely dependent on the type, age, and emission specifications for which the engine was designed to meet. The incomplete combustion of fuel results in soot-like carbon emissions being released into the atmosphere. Regeneration systems have been designed and installed on modern diesel engines to reduce these harmful emissions. Engine safety systems are designed to reduce power and even shutdown engines when operators fail to operate the regeneration system as designed. Equipment operators need a basic understanding of how these systems work and when to activate them to avoid engine malfunctions and job downtime.

Diesel particulate filter system

The diesel particulate filter (DPF) system is made up of a hydrocarbon doser, a diesel oxidation catalyst and a DPF. The hydrocarbon doser is used to spray a small amount of diesel exhaust fluid (DEF) into the exhaust system to help with the cleaning process. The diesel oxidation catalyst contains a solution of 32.5% urea, and 67.5% deionized water which is injected into the exhaust pipeline. This mixture reacts to generate heat in the exhaust system. The heat that is generated cleans or regenerates particulates into water and nitrogen, which are both harmless, before they enter the atmosphere. The DPF filters soot out of the exhaust and holds them for the regeneration process.

NOTE: It is the operator's responsibility to know the location of the tank and the amount of DEF still in the tank prior to operation.

Controlling the regeneration process

Equipment with regeneration systems installed normally have a switch mounted on the dash. These switches may have either two or three positions. The number of positions of this switch indicate what options operators have when operating the regeneration system. If the vehicle is equipped with a two position switch, the operator is able to manually begin the regeneration process; however, if the process begins automatically, the two position switch does **not** provide the operator with the ability to stop it. With this two position switch, the operator is required to wait until the process finishes.

Vehicles equipped with a three position switch, allows the operator to have extra control over the regeneration process. As with the two position switch, the operator is able to manually begin the process; however, the three position switch also enables the operator to end the process if it begins automatically.

NOTE: The ability to manually end the process that started automatically also makes the operator responsible for any damage that occurs as a result of this action. The effects of failing to allow a regeneration process to occur will be explained later.

Regeneration system function

The regeneration system will use hot gases produced by the engine during normal operations. This typically occurs during highway operation and requires no additional actions from the vehicle operator. This form of operation is referred to as passive regeneration and is transparent to the operation of the vehicle.

There are times when the exhaust gases fail to be hot enough for passive regeneration. Under these circumstances, the system will increase the exhaust temperature. This is referred to as automatic regeneration and is transparent to vehicle operation. An automatic regeneration cycle typically lasts 30 minutes. It should be noted that the temperature of the exhaust gases can reach as high as 1,200˚F during this process. Due to these temperatures, the tail pipe discharge should be avoided while regeneration is taking place. Warning lights and indicators on the main control panel informs the operator when this process is active.

There are times when the regeneration system is unable to raise the exhaust gas temperature high enough to activate the process. This occurs when the vehicle is driven at extended low speeds or with frequent start and stops; like you will see with snow removal operations. Equipment operators may face these conditions during certain construction jobs when working in confined areas or operating on unimproved roads. In such cases, warning lamps and indicator symbols will alert the operator that action must be taken. Operators need to be aware whether lamps are ON alone or in combination with others. Vehicle specific instructions will need to be followed as soon as possible to avoid severe engine malfunction and job downtime.

When the operating conditions are such that the regeneration system is unable to raise the exhaust gas temperature, the operator will be required to perform a parked regeneration process. The parked regeneration process is broken down into steps to allow for a general understanding of what is involved. It should be remembered that each vehicle with a regeneration system will have specific steps needing to be followed for that vehicle. Substituting steps intended for other equipment could lead to equipment malfunction and possible damage. Steps for a parked regeneration process are as follows:

1. Park the vehicle in a safe location.
2. Ensure no one comes near the area of the exhaust from the tail pipe.
3. Maintain a minimum of 5-feet clearance from combustible materials.
4. Check that all of the following are in place as failing to do so will prevent the regeneration from initiating:
    a) Parking brake applied.
    b) Engine running at low idle.
    c) DPF warning lamp illuminated.
    d) Coolant at operating temperature.
    e) Throttle, brake or clutch **NOT** applied.
    f) PTO disengaged.
    g) Transmission is in NEUTRAL.
    h) Cruise control switch is OFF.
5. Push and hold down the regeneration switch for at least 4–8 seconds to begin the parked regeneration process.

236. Preparing for snow removal operations on the airfield

The most critical times during an aircraft’s flight are takeoff and landing; therefore, the runway must be kept as free as possible of all hazards to aircraft operation, such as snow and ice. Excess snow makes driving hazardous and landing an aircraft extremely dangerous. Our job is to remove snow and

ice so that driving a vehicle, launching, and recovering of aircraft will be less hazardous. Snow removal isn't an eight-hour-a-day, five-day-a-week job; it's an around-the-clock job. It also takes proper planning and lots of snow removal equipment. Snow removal is a major effort particularly at northern tier bases. Effective snow removal is a very important operation that demands thorough planning. Many base agencies share in the planning responsibilities.

Responsibilities

Snow and ice control (S&IC) is a major responsibility; certain individuals on your installation share the bulk of the responsibilities for these operations:

- BCE.
- Chief of airfield management.
- Chief of heavy repair.

In the lesson, we'll briefly describe the responsibilities of these individuals.

Base civil engineer

The BCE is directly responsible to the support group commander for all S&IC activities on the installation. The primary responsibility of the BCE is to provide adequate facilities, equipment, and trained personnel for effective S&IC. This includes evaluating the environmental impact when de-icing chemicals are used on the airfield. The BCE selects individuals to make de-icing decisions based upon their position, experience, and environmental awareness. The BCE coordinates all installation snow removal and ice control activities through the civil engineer squadron (CES) operations' flight chief and the chief of heavy repair.

Chief of airfield management

To allow aircraft operations to continue, the chief of airfield management gives priority to S&IC equipment over all other flight line traffic. This individual is responsible for the publishing of orders and instructions with respect to vehicular traffic and communication procedures on airfield areas and flight line licensing for snow removal equipment operators. Additional responsibilities include directing runway condition readings (RCR) and runway surface conditions (RSC) to measure runway conditions when there's snow, ice, or slush on the airfield. The chief of airfield management coordinates these activities through base operations. As an operator, you'll work closely with base operations.

Chief of heavy repair

The chief of heavy repair is responsible for all S&IC operations, personnel, and equipment. This individual ensures all equipment is being used to the best advantage and that all safety and environmental precautions are being followed. The chief of heavy repair often plans the S&IC committee meeting that is held twice yearly.

Snow and ice control

AFI 32–1002, *Snow and Ice Control*, directs that all equipment must be mechanically sound and operational by 1 September of each calendar year. Installations receiving over six inches average annual snowfall should maintain a snow and ice control plan (S&ICP) and form a snow and ice control committee (S&ICC).

Snow and ice control operations

AFI 32–1002 generally lays out the format for the S&ICP. This document will include the following:

- Snowfall history.
- Equipment and required inventory.
- Equipment plowing patterns and team composition.
- Materials and parts level.

- Color-coded priority maps.

Final approval of the S&ICP is given by the wing commander.

NOTE: AF stations and small units such as radar sites will create plans to meet their own specific needs.

Snow and ice control committee

The S&ICC meets twice yearly. A preseason meeting should be held between September 1 and October 15. A postseason meeting is held between April 15 and May 31. During both meetings, the committee reviews the following information:

- Snow removal priorities.
- Organization responsibilities.
- Problems during the previous season.
- Contract needs for emergency S&IC.
- Levels of spare parts, materials, and de-icing chemicals.
- Manning and augmentee requirements.
- Status of snow equipment fleet.
- Off-season rebuild program.
- Annual depot repair needs.
- Chemical consumption and impacts on aircraft, airfield infrastructure, and the environment.

Although these subjects are discussed at both the pre- and postseason meeting, they receive more emphasis at the preseason meeting.

Priorities

Installation snow removal is normally categorized in three priorities–one, two, and three. The table lists the areas of consideration for each priority:

Priority	Areas
One	Primary runway and overruns. Primary runway access to taxiways and alert facilities. Apron access to taxiways. Aircraft crash equipment lanes. Access roads to special weapons, ammunition storage, refueling points, and other primary mission facilities. Primary access routes and from runway, navigational aids (NAVAIDS) for the primary instrument runway and to emergency facilities; that is hospital and fire departments.
Two	Secondary runways, overruns, and taxiways. Aircraft parking aprons and remaining aircraft movement areas. Access roads to secondary mission facilities and primary base streets. Covers NAVAIDS for those runways not covered in priority one.
Three	All other areas (low-priority base streets, military family housing, etc.).

Snow control center

As stated earlier, the focal point for all S&IC activities is the snow control center (SCC). As a minimum, the SCC should be equipped as follows:

- At least two class “A” telephone extensions for recalling off-base personnel.
- No less than one radio transceiver or remote. A dedicated net for snow removal communications when possible.

- Dispatch boards displaying vehicle registration numbers, nomenclature, vehicle status, dispatched location, operator, radio call sign, and comments.
- Appropriate layout maps with color-coded priorities, status, and runway surface conditions.
- Required publications including AFI 32–1002 and the S&ICP.
- Personnel rosters showing duty status and recall information.
- Chart identifying current weather conditions and forecast.
- List of alternate sources of equipment and personnel to support contingencies including instructions for renting equipment and DOD mutual support agreements with regional active or reserve units.

SCC personnel should carefully monitor use of ice control chemicals and log the quantities and locations the chemicals are used. At the end of the season, they are required to compile consumption data and report this information to the major command (MAJCOM).

Marking obstructions

Sound planning, properly trained people, and good leadership are a must for effective S&IC. S&IC begins long before the first snowfall is expected. As a preparatory step, all obstructions should be identified and marked so snow removal equipment won't impact them. One item of special importance that should be marked is the runway lights.

Runway lights

Runway lights are usually located in or just off the edge of the pavement. Airfield lights in the pavement may be elevated or flush mounted. If they're elevated, the airfield lights should be marked especially in heavy snowfall areas in the unlikely event that continuous snowfall covers the lights. One method is to saw pieces of one by two lumber halfway through, paint them yellow or orange, and stake them in the ground near each light. Ensure they are no taller than three feet (or whatever your local regulations state for airfield obstruction heights). Sawing them halfway through will ensure they break without damaging an aircraft should an aircraft hit any of them. Painting them orange or yellow will make them easier to see.

Another method is to plant an evergreen tree away from the runway and adjacent to each light or pick another reference point in the distance to use. Fiberglass poles are also commercially available. These methods may be used to mark other obstructions such as manhole covers, refueling pits, or even roadway boundaries.

Snow removal on the airfield

After the runway lights and other obstructions are marked and the snow removal equipment is readied for service, you're ready for the snow. Snow removal on airfields involves special problems because of the extreme width of the surfaces to be cleared. In addition, the decision of when to start snow removal operations must be made. In heavy snowfall regions, early snows should be plowed back far enough to allow for placement of later snows. At the first sign of snowfall, the shift supervisor should check the flight line for any signs of accumulation. When snow begins to accumulate, snow removal operations should begin. The supervisor's first priority and major concern is the airfield. Snow clearing on priority one areas must commence with the start of any accumulation to achieve the aim of continuous "bare pavement." Runway snow removal normally begins with the snow brooms. Snow brooms are used throughout the duration of the snowfall to maintain the center portion of the runway, down to bare pavement condition. During light snowfall, the scope of the operation should be enlarged to include the entire primary runway.

Snow removal must be given priority over aircraft operations on the runways when snow conditions might jeopardize runway serviceability and cause the installation to be closed to flying. To do this, close coordination and cooperation must be maintained between snow control (you) and base operations.

237. Operating techniques for flight line and main base snow removal

We begin this lesson by stating that snow removal is often performed best at high speed. For this reason, snow equipment operators can't always comply with airfield speed limits. Control tower personnel, aircraft ground maintenance personnel, and other vehicle operators should be advised of this and yield to S&IC equipment. With this in mind, let's turn our attention to the following three topics we'll cover in this lesson:

- Snow removal operation procedures.
- Communications.
- Operating under variable wind conditions.

Snow removal operating procedures

Snow removal conditions at individual bases may vary widely and require unique S&IC procedures and equipment. The rate of the snow accumulation will most likely determine the size and area in which to focus. Wind speed and direction may also determine your actual clearing pattern; however, snow removal operations should follow these general procedures as closely as possible:

1. Reduce operations and concentrate on keeping the center of the runway and taxiways open when snow accumulation prevents clearing an entire area.
2. Use plows in tandem to move snow into a windrow to be cast over the edge lights by a snow blower.
3. Clear enough snow to leave room for wings and engines. Determine permissible snow depth beyond the shoulders for the most demanding aircraft at the base.
4. Reduce the height of snow around glide slope critical areas to prevent aircraft communications signal loss. Keep runway and taxiway lights uncovered.

When removing snow, keep safe distances between vehicles operating in a snow removal pattern. This action will help to avoid accidents due to loss of vision. In addition, be sure to time equipment movements for an orderly turnaround and safe reentry at the start of the next pass.

Communications

All snow removal equipment operating in the area of aircraft movement must maintain radio contact with the control tower or be under the control of a supervisor (on-site snow control) in contact with the control tower. Before the shift leader exits the runway, he or she must physically check the entire runway to make sure all equipment has exited. Once the runway check is made, the shift leader may then exit the runway and inform the control tower that all equipment is off the runway. All operators must stay off the runway (beyond the "hold short" line) until informed by the shift leader to resume operations.

Operators must keep radio communications to a minimum on the snow control frequency during runway snow removal operations. Unrelated communication can lead to confusion. When a multiple user-net system is used, snow removal operations must be given priority.

Operating under variable wind conditions

Plow operations aren't as affected by adverse winds to the same degree as blower operations. If it is impractical to blow snow with the wind, you may have to postpone dispersal of the windrows until the wind direction changes.

In such cases, use plows to knock down the windrow heights until they can be removed. Let's take a look at the following two distinct wind conditions that affect snow removal:

- Calm and parallel winds.
- Crosswinds.

Calm and parallel wind conditions

During calm and parallel wind conditions, start snow removal with snow brooms at the end of the runway, to one side of the centerline, and work toward the shoulders. When the windrows of snow get too heavy for the sweeping operation, use plows to displace it. By clearing the centerline first, you maintain the runway in a state of operational readiness and available for aircraft movements.

Crosswind conditions

When crosswinds are combined with a heavy snowfall, you must concentrate snow removal operations on the runway centerline area. Use one sweeper to straddle the centerline at all times. Begin passes on the upwind side of the centerline working with the wind. Let the wind help you move the snow across the runway if time and aircraft operations permit. Once you start this clearing operation, you must continue it for the entire width of the runway. This is done to avoid obscuring the runway centerline or leaving a windrow. If available, use a snow blower to blow snow completely off the runway area and over the lights where snow has been plowed into windrows. You'll also need to maintain close coordination with the control tower at all times. Doing so ensures control tower personnel are aware of windrows, snow banks, or slush if you must stop clearing operations before finishing the entire runway width.

Clearing snow from lights, aircraft arresting systems, and other areas

When operating large equipment such as snow removal equipment, it's hard to imagine you can use the same equipment that clears runways to clear snow from around small objects or in confined areas. However through lots of experience, it can be done. We'll discuss techniques used to clear snow from the following specialized areas:

- Runway-edge lights.
- In-pavement lights.
- AAS.

In addition to these, we'll also look at clearing other airfield areas and base-side snow removal operations.

Runway-edge lights

Lights are an integral part of the runway system. You must keep them clear from snow so pilots can see the lights. To keep the lights visible, you can use the air-blast from snow brooms when the snowfall is light. During heavier snow conditions—when snow removal operations are concentrated on the runway centerline—one snow broom may have to make continual passes to keep the lights clear.

During severe snow conditions, you may have to use a rollover plow periodically to clear a path in front of the lights. Then use the air-blast from the sweeper to blow snow away from the lights. If the snowfall is wet and heavy, or it's impossible to keep them clear due to heavy snowfall, hand shoveling may need to be done by a crew to keep the lights uncovered. When the snowfall has stopped, graders and front-end loaders can be used to clear around the lights during clean-up work.

NOTE: Snow removal equipment should not be operated off the paved surface unless the surface is sufficiently frozen, or paved shoulders exist.

In-pavement lights

The raised runway centerline, exit taxiway turnoff, and touchdown zone light fixtures will present a problem if packed snow, slush, or ice form on them. To prevent damage to the lights, caution should be used when operating a snow plow over the area. If the plow is equipped with a steel blade, it should be kept in a slightly raised position to clear the top of the lights. The snow broom or a rubber cutting edge on the plow should be used whenever possible to keep this area clean.

Aircraft arresting systems

Before beginning to clear snow, the aircraft arresting systems will need to be deactivated. Personnel responsible for these systems will deactivate them. When removing snow, you'll need to remove enough to allow full use of the AAS. Portable snow blowing equipment and manual labor may be required to clean sufficiently around the AAS. Use AAS maintenance or augmented personnel for this work.

Other airfield areas

Snow removal that requires hand shoveling, small rotary blowers, or small tractor-mounted plows is generally the responsibility of the facility occupants or manager. This includes removing snow from areas around parked aircraft, hangars, shelters, grounding points, NAVAIDS, arresting systems buildings, and other areas you can't safely clear snow using snow removal equipment.

Base-side snow removal operations

Many of the same methods for airfield snow removal are used for nonairfield areas; however, snow brooms, rollover plows, and blowers are seldom used on base streets. Graders, loaders, and dump trucks with plows and spreader attachments are typically used on base streets. Keep in mind that safety is more critical on base streets since they're more narrow and congested.

238. Ice control chemicals for pavements

There's no doubt that ice and compacted snow on paved surfaces creates hazardous conditions. Failure to eliminate ice and hard packed snow from airfield surfaces can result in closure, thereby jeopardizing the mission of the installation. It can also lead to unnecessary accidents and injuries.

Chemicals that aren't corrosive to aircraft materials and effective at reducing the hazards are available for use on airfield surfaces. Some chemicals are very effective when used in conjunction with the correct snow and ice control techniques and within certain temperature ranges. You can't use ice control chemicals in a haphazard manner; instead, their use is strictly controlled. In fact, the only anti-icing and de-icing agents authorized for airfield pavements are those recommended by the Headquarters Air Force Civil Engineer Center (HQ AFCEC). In this lesson, we'll be discussing many varied but related ice control subjects:

- Influencing factors for ice formation.
- Runway ice detection systems (RIDS).
- S&IC mobile detection equipment.
- Anti-icing procedures.
- De-icing.
- Abrasives.

Influencing factors for ice formation

There are several factors that influence the formation of ice on pavements, they are as follows:

- Surface color and composition.
- Wind.
- Humidity.
- Solar radiation.
- Traffic.
- Residual de-icing chemicals.

Air temperature alone isn't an accurate gauge to determine pavement surface conditions. Knowing the rate of change of pavement temperature allows you to predict ice formation. In addition, knowing the pavement temperature when ice or compacted snow accumulates on the paved surfaces will help you choose the right chemical and amount to use to get the most effect with the least amount of material.

NOTE: Mechanical de-icing (underbody scraper blades or graders used in conjunction with snow brooms) should be used to reduce ice thickness before resorting to chemicals.

Runway ice detection system

The RIDS is particularly valuable for timing anti-icing applications of chemicals. This system minimizes the use of chemicals and aids in protecting the environment. RIDS consist of clusters of sensors resembling hockey pucks which are embedded in the runway. These sensors are hard wired to a remote processing unit (RPU) which can be monitored by base operations personnel. The RPUs collect data from these sensors that include the surrounding ground level weather data and transmit the information to a central processing unit (CPU). This system collects, transfers, processes, and displays data in a clear, concise, and easily understood format on a display console. This continuous data includes the following:

- Dry and/or wet pavement.
- Surrounding temperature at ground level.
- Relative humidity.
- Wind speed and direction.
- Subsurface temperature.
- Precipitation.
- Dew point.
- Residual chemical factor.

The CPU has the ability to store historical data from each sensor for future reference. Supervisors can access historical data to see precisely when chemicals were needed, when they were applied and how effective they were. With this system, you can forecast pavement conditions up to 24 hours in advance. This takes much of the estimation out of snow and ice removal. Properly calibrated dispensing equipment can apply the minimum required amount of anti-ice/de-icer precisely where it's needed, as close as possible to the time it's needed for maximum effectiveness.

The system is very expensive to install and maintain and may not be available at your installation. For this reason, the now snow and ice control mobile detection equipment (SNIC) system is more prevalent.

Snow and ice control mobile detection equipment

The advancement of computers, global positioning systems, and wireless communication has led to the use of a mobile unit known as SNIC. The SNIC system gives all the same information that the RIDS can and allows for the RCR to be completed with a tow behind grip tester. The RCR data can be input into a laptop computer and formulate chemical requirements for anti-icing/de-icing action on the airfield.

Anti-icing procedures

S&IC teams with RIDS or SNIC systems in place should emphasize anti-icing rather than de-icing whenever possible. The primary effort of ice control should be to keep ice from bonding to the pavement. During freezing rain conditions, use snow brooms to reduce standing water to a minimum. Anti-icing requires applying liquid de-icing chemicals before freezing conditions occur. The most effective chemicals for anti-icing are those in liquid form.

De-icing

De-icing can require five times as much chemical as anti-icing. After applying the de-icer, you'll need to wait for the chemical to take effect. After the ice begins to break up, it can be removed with snow brooms or snow plows.

Abrasives

Abrasives should be used only under emergency conditions to improve traction on airfield surfaces. When an abrasive is needed, use only Federal Aviation Administration (FAA)-grade and MAJCOM approved sand that's clean, free running, and contains no loam or clay. The correct grade is 100 percent passing a No. 4 sieve and not more than 30 percent passing a No. 5 sieve. Heating the abrasive prior to applying helps it stick to the ice making it more effective.

Dispensing anti-icing and de-icing chemicals

Because chemicals may cause melting and increase ice formation, avoid using them during the early stages of a dry snowfall or under windy conditions.

Solid chemicals

For uniform coverage on the airfield, chemical dispensers should have a capacity between five and seven cubic yards. In addition, the dispenser must accurately dispense the chemicals. The dispensers must be able to apply a uniform pattern at various density settings. When possible, use solid chemical dispensers with pre-wetting capabilities. Pre-wetting solid de-icers-ith approved liquid de-icers are more effective at lower temperatures and will prevent the solid de-icers from being blown off the surface by high winds.

Both sodium-formate and sodium acetate are solid chemicals that have proven themselves in field tests and have been recommended for AF use. They're safer for the environment than urea and are more effective (down to 5° F).

Liquid chemicals

Use trucks equipped with tanks and spray bars to dispense the liquid chemicals. Also, the truck should have a gauge or computer system to accurately measure the amount and specific application rates attained of the chemical. Correct spreading should allow the spray bar and nozzles to cover the area well without excessive runoff. Portable towed tanks and water distributors may be used, but these will require flushing if used for multiple activities.

Currently, the most environmentally acceptable liquid ice control agents are potassium acetate de-icers. Potassium acetate chemicals that meet the Society of Automotive Engineers Aerospace Materiel Specification (SAE AMS) 1435 specifications can be used. The following table shows the application rates.

Potassium Acetate—Gallons Per 1,000 Square Feet (See Note)			
Ice Thickness	**Pavement Temperature**		
	20°F–32°F	10°F–19°F	Less than 10° F
Less than 1/32"	.9	1.2	1.8
1/32"–1/8"	1.2	1.8	3.0
1/8"– ¼"	1.8	2.7	6.0

NOTE: When freezing conditions are expected to occur, you can use potassium acetate as an anti-ice chemical at the rate of .4 gallons/1,000 square feet.

Storage

Whenever possible, chemicals should be stored in enclosed shelters. This reduces environmentally caused degradation of the chemicals. If abrasives are stored outside, moisture absorbed by these chemicals may cause stockpile to freeze or become unusable in cold weather. Storing liquid ice control chemicals in tanks must comply with all applicable regulation for hazardous materials. Potassium acetate chemicals should be stored in polyethylene or stainless steel tanks.

Ice control chemicals for streets and parking areas

In our last lesson, we looked at the chemicals used to control ice on flight line areas. In this lesson, we'll turn our attention to the chemicals you can use to treat base streets and parking areas. Basically, this treatment falls under these two categories–chlorides and abrasives; however, potassium acetate can be used as well; it is just extremely expensive to be spraying on streets.

Chlorides

Sodium chloride (rock salt) and calcium chloride are effective for ice control measures on streets and parking areas. As with using flight line chemicals, use these chemicals as little as possible. In addition, care must be taken at sites where these chemicals are stored. Keeping the chloride de-icers dry will prevent ground or surface water contamination. Use these chlorides as follows:

- Use sodium chloride and calcium chloride for de-icing non-airfield areas only. Because these chemicals are highly corrosive, they should never be used near aircraft movement areas.
- Use sodium chloride (with or without added liquid calcium chloride) to de-ice base areas. This is more effective and economical.
- Use calcium chloride instead of sodium chloride at lower temperatures. Pre-wetting will make it even more effective. Chloride-based de-icers with corrosion inhibitors may be used on bridges or other metal structures.

Abrasives

Using sand, cinders, and fly ash will increase vehicle traction on icy surfaces. To improve traction and melt ice, you can add between five and 15 percent chloride to sand. Although abrasives may improve traction on icy pavements, you must limit their usage. Heavy applications can insulate the ice and keep it from melting. It may also degrade air quality in windy locations and cause drainage problems. Because of this, drainage inlets should be routinely cleared. This reduces the possibility of flooding when the ice and snow melt.

Local environmental regulations may limit the use of any chemical used in ice control operations; you will need to be aware so no unauthorized materials are used.

Storage

As you read earlier, chemicals should be stored in enclosed shelters whenever possible. Chlorides are no exception. If abrasives are stored outside, moisture absorbed by these chemicals may cause the stockpile to freeze in cold weather.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

235. Snow removal equipment

1. What is the purpose for the quick-connect on the MSRU?

2. What type of plow should you use to plow a confined area where it is easier to change the plow angle than to deadhead?

3. How can you keep your speed up when plowing windrows with a rollover plow?

4. What purpose does the shoes on a plow or blower head assembly serve?

5. List three other types of equipment you can use in snow removal operations.

6. What is one of the major advantages of a front-mounted snow broom versus a towed-type broom?

7. What is used to generate extreme heat in the exhaust system?

8. When operating conditions prevent an automatic regeneration, what is required of the operator?

236. Preparing for snow removal operations on the airfield

1. Who is directly responsible to the support group commander for all S&IC activities?

2. With whom does the BCE coordinate all snow removal and ice control activities?

3. What must the chief of heavy repair ensure?

4. What publication directs that all snow removal equipment must be mechanically sound and operational by 1 September of each year?

5. What information *must* be available for the pre-season committee meeting?

6. What snow removal priority includes primary base streets?

7. At the end of the snow removal season, the SCC reports to what agency with the quantities of chemicals used?

8. Why are the pieces of lumber, sawed halfway through, used to mark runway lights?

9. In heavy snowfall regions, how are the first snowfalls plowed?

10. When does snow clearing on top-priority areas begin?

11. When is snow removal equipment given priority over aircraft operations on the runway?

237. Operating techniques for flight line and main base snow removal

1. During snow removal operations, what must the shift leader do prior to exiting the runway?

2. What are two distinct wind conditions that affect snow removal?

3. How should snow removal operations begin under calm or parallel wind conditions?

4. When removing snow under crosswind conditions, why must you continue the operation for the entire width of the runway?

5. What kind of snow condition requires using the air-blast from the snow broom to make periodic passes to clear the runway lights?

6. How is snow removed from runway lights when the snowfall is too heavy to keep them clear?

7. How do you remove snow from the immediate vicinity of the AAS?

8. Who is responsible for removing snow from areas where snow removal equipment cannot be operated?

238. Ice control chemicals for pavements

1. What allows you to predict ice formation on pavements?

2. What purpose does the CPU system serve on the RIDS?

3. RCR can be conducted with what type of equipment?

4. Under emergency conditions, what is the only type of abrasive you can use on airfield surfaces?

5. How should potassium acetate be stored?

6. What two chemicals are effective as ice control measures on streets and parking lots?

7. What type of chemical should be used at lower temperatures?

8. When dispensing abrasives, what can result if you apply too much?

9. What may happen if abrasives are stored outside?

Answers to Self-Test Questions

226

1. Using a fill station.
2. Slower pressure may cause the hose to come out of the tank and possibly hitting someone and the opening valve nut on the hydrant can be rounded off by use of the incorrect wrench size.
3. If you make a sudden turn, the water sloshing from side to side may cause you to lose control.
4. Eye goggles.
5. When the pump is empty of water, or when air is allowed to enter the intake.
6. Dig a sump pit.

227

1. From the bottom and work to the top.
2. This maintains the crown and drainage of the job site.

3. Vibrations are created by the steel drums which produce a rapid series of impacts that created pressure waves. This pressure waves penetrate the soil, setting particles in motion to fill voids between the grains.
4. A fine spray of water from the spray bars.
5. To make final passes over an area that has been first compacted by a sheepsfoot roller.
6. Both are mounted on two tandem axles with smooth treaded tires arranged so the rear ones cover the spaces left by the front ones.
7. To eliminate uncompacted strips.

228

1. A three-point hitch.
2. By letting the swinging drawbar swing free.
3. Delivers power from the tractor engine to the mounted or attached equipment.
4. Lower the auger gradually into the ground until the hole is about one foot deep. Then raise the auger to remove the soil. Repeat until the hole is at the desired depth.
5. Leveling, backfilling, and light-clearing work.

229

1. The BCE.
2. Before you operate any equipment on the flight line, you must first receive special flight line training at your base of assignment and have this annotated on an AF Form 483, Certificate of Competency.
3. Make frequent visual checks with the control tower for warning and clearance light signals.
4. Base operations.

230

1. Keeping the machine clean.
2. High velocity air.
3. Skimmed off in the separator.
4. Curb and gutter work.

231

1. (1) Hopper doors.
   (2) Inspection doors.
   (3) Fluid levels and air cleaners for both engines.
   (4) Lights.
2. Because of the continuous dusty operating conditions.
3. Determined by the amount of debris and obstacles present.
4. To clean around immovable objects and to can cleanup leaves in corners and other hard to reach places.
5. To allow seals to dry and regain their shape.
6. Poor sweeper performance will result.
7. By keeping the spring tension suspension system in proper adjustment.
8. The broom could hang on a stationary object and break off.
9. (1) Spring.
   (2) Tilt.

232

1. Inside the cab from a panel located to the operator’s right.
2. Open the throttle to near full. This will help prevent the snow from packing up inside the brush hood.
3. When the broom is working with the sides of the bristles, and not just the tips.
4. Sweeping at a high enough broom speed and low enough ground speed. Watch the material as it leaves the broom and periodically check behind you.

233

1. Towed and self-propelled.
2. Spin the tires.
3. Hopper, conveyor, operator’s station, screed control stations, screed.

234

1. So that material will pass smoothly under it.
2. To account for compaction of the material.
3. It can lead to an inferior surface.
4. Asphalt release agent or heat.

235

1. Enables you to interchange between a blower, displacement plow or front sweeper.
2. Reversible.
3. By taking less than a full blade of snow or by drifting out of the windrow until you regain your speed and then pulling back into the windrow.
4. Support the weight of the plow and/or blower head assembly protecting the moldboard from being worn or damaged.
5. (1) Bulldozer.
   (2) Grader.
   (3) Front-end loader.
6. It can sweep the area before the broom caster wheels or truck tires pack the snow; the operator has a clear vision of the area to be swept, and a faster forward speed is achieved.
7. Diesel Exhaust Fluid (DEF).
8. A parked regeneration process

236

1. The BCE.
2. Operations flight chief and the chief of heavy repair.
3. All equipment is being utilized to the best advantage, and all safety and environmental precautions are being followed.
4. AFI 32–1002, *Snow and Ice Control*.
5. Status of equipment.
6. Priority two.
7. MAJCOM.
8. To ensure they break without doing any damage to an aircraft should an aircraft hit one of them.
9. Back far enough to allow for placement of later snows.
10. With the start of any accumulation.
11. When snow conditions would jeopardize the runway serviceability and cause the installation to be closed to flying.

237

1. Physically check the entire runway to make sure all equipment has exited.
2. (1) Calm and parallel conditions.
   (2) Crosswind conditions.
3. Start with snow brooms at the end of the runway, to one side of the centerline, and work toward the shoulders.
4. To avoid obscuring the runway centerline or leaving a windrow.
5. When snowfall is light.

6. By a detail hand shoveling. during heavier snow conditions—when snow removal operations are concentrated on the runway centerline—one snow broom may have to make continual passes to keep the lights clear.
7. Use portable snow blowing equipment and manual labor.
8. Facility occupants or manager.

238

1. Rate of change of pavement temperature.
2. This system collects, transfers, processes, and displays data in a clear, concise, and easily understood format on a display console.
3. Grip tester.
4. FAA-grade sand that's clean, free running, and contains no loam or clay.
5. In polyethylene or stainless steel tanks.
6. Sodium chloride (rock salt) and calcium chloride.
7. Calcium chloride.
8. Heavy applications can insulate the ice and keep it from melting.
9. Moisture absorbed by these chemicals may cause the stockpile to freeze in cold weather.

Complete the unit review exercises before going to the next unit.

Unit Review Exercises

Note to Student: Consider all choices carefully, select the *best* answer to each question, and *circle* the corresponding letter. When you have completed all unit review exercises, transfer your answers to the Field-Scoring Answer Sheet.

Do not return your answer sheet to the Air Force Career Development Academy (AFCDA).

89. (226) The first task in operating a water truck is to
    a. open all valves.
    b. fill the water tank.
    c. start the water pump.
    d. connect the spray bar hoses.

90. (226) The ballast plates inside the tank of a water truck are designed to
    a. separate the water in the tank.
    b. maintain the desired water level.
    c. prevent excessive water movement.
    d. give additional strength to the tank.

91. (226) What factor is the *most* important in determining how well soil can be compacted?
    a. Degree of aggregate gradation.
    b. Degree of moisture in the soil.
    c. Percent of course aggregates.
    d. Percent of fine aggregates.

92. (227) The one to two inches of loose material left by a sheepsfoot roller
    a. is hauled away.
    b. is used to absorb moisture.
    c. acts as a cushion for the final layer.
    d. assists in bonding successive layers.

93. (227) What piece of equipment is usually used to tow a sheepsfoot roller on a construction site?
    a. Dozer.
    b. Scraper.
    c. Pick-up truck.
    d. Industrial tractor.

94. (227) What is the purpose of equipping steel-wheel rollers with scraper blades?
    a. Assist in leveling the area.
    b. Break up hardened surface areas.
    c. Keep the drum rolls in proper alignment.
    d. Keep the drum rolls clean and free of debris.

95. (227) When using a steel-wheel roller to roll asphalt, how can you prevent the drive roll from pushing the asphalt up in front of the drum?
    a. Drive the roller backward.
    b. Drive the roller forward.
    c. Increase the vibrations.
    d. Use plenty of water.

96. (227) What can happen if you leave the steel-wheel roller standing on a new road surface?
    a. The heat will warp the drum rolls.
    b. Depressions may be left in the pavement.
    c. Segregation will take place in the asphalt.
    d. Engine oil may leak and deteriorate the asphalt.

97. (227) One difference between the self-propelled pneumatic roller and the 13-wheel towed roller is that the self-propelled roller
    a. travels faster.
    b. has a dozer blade.
    c. has a watering system.
    d. can maneuver in smaller areas.

98. (227) How can you ensure uniform compaction with the pneumatic-tired roller?
    a. Maintain even tire pressure.
    b. Overlap each succeeding pass.
    c. Begin rolling on the west side.
    d. Begin rolling on the outside edge of a project.

99. (228) The *most* convenient way to mount equipment on an industrial tractor is with a
    a. pintle hook.
    b. floating drawbar.
    c. three-point hitch.
    d. swinging drawbar.

100. (228) When, if ever, should the power takeoff (PTO) *not* be engaged on an industrial tractor fitted with a PTO?
    a. If the hydraulic pressure drops below safe limits.
    b. When maintenance personnel are working on the tractor.
    c. When no PTO-driven equipment is mounted to the tractor.
    d. The PTO is always engaged when the tractor is operating.

101. (229) What method is the *best* way to perform an airfield sweeping and inspection operation?
    a. Drive fast to cover more area in less time.
    b. Get out of the vehicle and walk around the area.
    c. Drive slowly and move back and forth across the area.
    d. Proceed up one side of the airfield then down the other.

102. (230) The air sweeper is *best* described as what type of machine?
    a. Dry sweep.
    b. Wet sweep.
    c. Open-loop.
    d. Closed-loop.

103. (230) How is fine dust removed from the air stream before it returns to the air sweeper’s blower?
    a. Skimming it off in the separator.
    b. Passing it through a screen separator.
    c. Forcing it over an adhesive coated plate.
    d. Forcing it through a series of filter bags.

104. (231) What action *must* you take frequently when using the air sweeper to sweep over wet pavement?
    a. Change the revolutions per minute (RPM).
    b. Visually check the hopper.
    c. Dump the sweeper hopper.
    d. Raise the sweeper head.

105. (231) When using the handheld suction hose on the air sweeper, you should *never*
    a. wash out the hose.
    b. pick up glass bottles.
    c. allow dirt to enter the open end of the hose.
    d. direct the hand hose toward another person.

106. (231) For *best* results and prolonged sweeper parts life, how should you wash the air sweeper hopper?
    a. Back toward the front of the hopper.
    b. From the right and left inspection doors first.
    c. Start from outside and work toward the inside.
    d. Start from the inside and work toward the outside.

107. (231) When should you change the air sweeper gutter broom bristles?
    a. After 40 hours of use.
    b. Only after they become brittle.
    c. Not required to change bristles.
    d. Per owner's manual or technical order.

108. (232) Depending on conditions, how many miles per hour can a front-mounted broom-sweeping unit remove light debris from paved surfaces?
    a. Six.
    b. Seven.
    c. Eight.
    d. Nine.

109. (232) Which factor is *not* an issue in controlling the brush life on the front-mounted broom?
    a. Ground speed.
    b. Broom moisture.
    c. Brush down pressure.
    d. Keeping the broom level.

110. (233) Paving machines are available in what paving lane widths (in feet?)
    a. 4–10.
    b. 6–12.
    c. 4–16.
    d. 6–18.

111. (233) What type(s) of drive systems are available for self-propelled pavers?
    a. Tracks only.
    b. Wheels only.
    c. Wheels and tracks.
    d. Rollers and wheels only.

112. (233) What percent of compaction can you expect from the vibratory screed of a paving machine?
   a. 65.
   b. 75.
   c. 85.
   d. 95.

113. (234) You raise the screed slightly prior to starting paving operations to
   a. account for the size of the aggregate in the mix.
   b. account for the compaction of the material.
   c. create a depression for drainage.
   d. create a hump for drainage.

114. (234) The substance that can be used to aid in the clean-up of the paving machine is an asphalt
   a. release agent.
   b. emulsifier.
   c. prime coat.
   d. acid wash.

115. (235) What *advantage* do you gain when using a front-mounted snow broom?
   a. Can be used in reverse.
   b. Does not need a prime mover.
   c. Operates at faster forward speed.
   d. Brushes are heated to reduce snow buildup.

116. (235) What may cause the regeneration process from reaching a high enough exhaust gas temperature to activate the process?
   a. Low ambient temperatures.
   b. Vehicle driven at extended low speeds.
   c. Improper mixture of diesel exhaust fluid.
   d. Lack of diesel exhaust fluid in the reservoir.

117. (236) Who is *directly* responsible to the support group commander for snow and ice control activities?
   a. Shift leaders.
   b. Base civil engineer.
   c. Deputy base commander.
   d. Chief of airfield management.

118. (236) The snow and ice control (S&IC) center should be equipped with
   a. a flying schedule.
   b. at least one class “A” telephone.
   c. color-coded layout maps showing priorities.
   d. charts showing the previous year’s snow fall.

119. (236) Normally, what type of snow equipment would you use to begin runway snow removal?
   a. Plow.
   b. Blower.
   c. Brooms.
   d. Vacuum.

120. (237) When the windrows get too heavy for the sweeping operation, what equipment should you use to displace the snow?
    a. Plows.
    b. Snow blowers.
    c. Front-end loaders.
    d. Steel bristle brooms.

121. (237) When crosswinds are combined with a heavy snowfall, where must you concentrate snow removal operations?
    a. Runway edge.
    b. End of runway area.
    c. Aircraft parking areas.
    d. Runway centerline area.

122. (238) What is the runway ice detection system (RIDS) designed to minimize?
    a. Chemical usage.
    b. Air blast sweepers.
    c. Underbody scrapers.
    d. Runway condition readings.

123. (238) Which reading is *not* collected by the central processing unit (CPU) of the runway ice detection system (RIDS)?
    a. Ice thickness.
    b. Relative humidity.
    c. Subsurface temperature.
    d. Wind speed and direction.

124. (238) Which chemicals are highly corrosive to metals and should never be used near aircraft movement areas?
    a. Urea and rock salt.
    b. Urea and isopropyl alcohol.
    c. Sodium chloride and calcium chloride.
    d. Potassium acetate and propylene glycol.

Glossary of Abbreviations and Acronyms

AAS	aircraft arresting system
AF	Air Force
AFCEC	Air Force Civil Engineer Center
AFI	Air Force Instruction
AFOSH	Air Force Occupational Safety and Health
AFCEC	Air Force Civil Engineer Center
AT	all terrain
BCE	base civil engineer
C/B	center of balance
CDC	career development course
CE	civil engineer/cvil engineering
CES	civil engineer squadron
CG	center of gravity
CPU	central processing unit
CTL	compact track loader
DEF	diesel exhaust fluid
DOD	Department of Defense
DOT	Department of Transportation
DPF	diesel particulate filter
FAA	Federal Aviation Administration
F/L	forklift
FOD	foreign object damage
HQ	Headquarters
Hz	hertz
kV	kilovolt
lbs	pounds
LC	lubrication chart
LG	lubrication guide
LMI	load moment indicator
MAJCOM	major command
MHE	material handling equipment
MILL	maximum load limit
mph	miles per hour
MSRU	multipurpose snow removal unit

NAVAIDS	navigational aids
NCO	noncommissioned officer
ORM	operational risk management
OSHA	Occupational Safety and Health Administration
P&E	pavements and equipment
PPE	personal protective equipment
psi	pounds per square inch
PTO	power takeoff
QTP	qualification training package
RADR	rapid airfield damage repair
RCR	runway condition reading
RIDS	runway ice detection systems
RPM	revolutions per minute
RPU	remote processing unit
RSC	runway surface condition
RT	rough terrain
SAE AMS	Society of Automotive Engineers Aerospace Materiel Specifications
SCC	snow control center
S&IC	snow and ice control
S&ICC	snow and ice control committee
S&ICP	snow and ice control plan
SNIC	snow and ice control mobile detection equipment
SuPR	sustainment pavement repair kits
SWL	safe working load
TO	technical order
TPH	tons per hour
UV	ultraviolet
VIL	vehicle identification link
WLL	working load limit

Student Notes

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