Earthmoving machines

Earthmoving machines include motor graders, tractors, tractor-scrapers, bulldozers and similar equipment. Hazards can be associated with the operation of these machines, not only because of their size and power but also because they are operated on uneven, unstable surfaces. This data sheet points out the various hazards involved and gives procedures needed to avoid personal injury to workers and other personnel.

1. The primary sources of injury are:
   - Slips and falls while getting on and off machines
   - Repairing and servicing equipment
   - Striking individuals or other machines with equipment
   - Unexpected shocks to machinery
   - Uncontrolled traffic within or through the work area
   - Sudden movement of machines while they are being attached to other earthmoving equipment
   - Pinch points between equipment and other objects in motion
   - Limbs of trees or overhead obstructions
   - Leaving equipment unattended while being serviced
   - Failure of lifting mechanism
   - Machine component failure due to poor maintenance, defective welds, and metal fatigue

**Assuring safety**

2. Management can assure a greater degree of safety by careful selection of machine operators, by providing proper safety equipment for both operators and machines, and by enforcing adherence to all safety rules.

**Selection and training of personnel**

3. It is management’s responsibility to carefully select operators for earthmoving equipment. Operators should have a preplacement medical examination before being considered as operators, followed by established, periodic physical examinations after placement. Before beginning a job, operators should be given instructions regarding the work to be done and the correct safety procedures.
Personal safety equipment

4. To prevent hand injuries, operators and their helpers should use heavy gloves when handling cables. Hands should always be kept away from danger points (i.e., rope sheaves and other working parts).

5. All operators should wear eye protection, gloves, safety hats and other personal protective equipment as required by conditions and for the particular job to be done. Protective equipment should be kept as clean and dry as possible so it provides maximum safety.

6. Personnel should wear slip-resistant shoes because slipping hazards can be present. Shoes should be kept as clean and as dry as possible.

7. Ground personnel working in the near vicinity of moving machines should wear a high visibility vest to aid the machine operator in seeing them.

Machine safety equipment

8. All new machines that are identified in regulatory requirements must be equipped with rollover protective structures that comply with the applicable criteria. Screens or shields may be needed to protect the operator from falling objects when hazards exist, such as in logging and site clearing operations. These devices must comply with applicable requirements. Welding on, drilling holes in, or making any modification to Roll Over Protection System (ROPS) or Falling Object Protection System (FOPS) is not permitted without approval from the manufacturer because of the potentially serious effect on the performance capability in a rollover or in resisting a falling object.

9. Installation and use of a seatbelt is required on all machines with a ROPS. It is recommended that any machine that is driven in traffic on public highways be provided with a seat belt.

10. Handholds and handrails properly oriented with steps should be provided and maintained so personnel can maintain three-point contact while climbing on, off and around a machine.

11. All bi-directional machines with an obstructed view to the rear shall be equipped with an audible reverse alarm device that operates automatically when the machine is in reverse motion unless there is a traffic control person designated to specifically direct the machines. Other suitable means may be applicable.

Basic operating rules

12. General and specific operating rules for the various types of equipment should be established. All operators should be established. All operators should be instructed in the hazards connected with their work and shown the safe methods of operation.

13. Copies of the equipment manufacturer’s instruction manual should be kept with each machine and all operators told to refer to it whenever any doubts concerning operating procedures become apparent. Operators also should be instructed to consult with their supervisor if the manual does not cover a special situation. Basic operating rules include:

- Operators climbing on and off equipment should maintain three-point contact with the machine (i.e., two feet and one hand or two hands and one foot on the handholds, handrails and steps of the machine).
- Before using the starting motor, operators or mechanics should check to ensure all operating controls are in the neutral position.
- Before moving earthmoving equipment, operators should make certain no other personnel are in the danger area around the equipment. The best procedure is for an operator to walk around the machine before starting it.
- Machines should be operated at speeds and in a manner consistent with conditions of the particular job.
- A machine should be driven slowly off the shoulder of a road to avoid dropping of one wheel, causing a sudden tilting and possible loss of control of the machine.
• When parking to leave a machine, the machine operator should apply the parking brake, lower the dozer blade and all other equipment to the ground or to a secured position, place the shift lever in neutral with provided locks engaged, and shut down the engine. The electrical master switch, if provided, should be turned off. Operators should follow company shutdown procedures to prevent unauthorized starting of the machine. All machines should be left parked on level ground or secured with chocks or equivalent devices if not on level ground and located, where possible, in places inaccessible to children and unauthorized persons. Note: At no time should a machine be left unattended with its engine running.

• If possible, machines should not be driven or parked on public roads after dark. If night work is necessary, the machine should be provided with adequate lights and reflectors to illuminate the road and the machine so other drivers can see it. When any portion of parked equipment projects into the road, day or night, it should be adequately marked with barricades, red flags, red lights or flares.

• When equipment is in use on a section of road, it is advisable to place “Danger Ahead” signs at sufficient distances and at both ends of the operation to warn oncoming traffic. Warning signs should be placed at least 1,500 feet from the starting point of the operations or barricade on highways and at an even greater distance if traffic speed indicates. Instructive and informational signs should be placed as needed, between the warning signs and at the start of the operations. Note: Be sure to observe local, state and federal traffic regulations pertaining to warning signs, etc.

• Left-hand traffic patterns should be avoided. However, such a pattern may be justified in mountainous terrain or where it is necessary to keep loaded units on the inside of the road.

• Operators should not allow other personnel to ride on equipment while the equipment is in motion, except for training purposes, and then only when a seat is provided. No one should be allowed to climb onto equipment in motion.

• When reeling a wire rope on a drum or through sheaves, operators should disengage the master clutch, idle the engine and lock the brakes. Note: All operators should stop engines before working with ropes wound on front-mounted drums.

**Special operations**

14. Additional safety precautions apply when operating earthmoving equipment in certain areas.

**Slope operations**

15. When sloping banks, operators should be alert for rocks, logs and trees.

16. Tools, such as dozers and buckets, should be kept close to the ground for balance when the machine is traveling especially on a slope.

17. Operators should always keep the machine’s transmissions in gear when traveling to provide engine retarding and to maximize the operator’s ability to control the machine. The machine’s retarder, if the machine is so equipped, should be used to control travel speed downgrade. Travel downgrade in the transmission gear selected to retard the machine with minimum use of service brakes.

18. Another method of retarding forward motion when dozers are to be operated down a steep slope is to keep the blade full of material so it helps control machine braking and steering. If the blade loses the load, stop the machine with its brakes and carefully reload the blade. Use the brakes, not the lowered dozer blade, to stop a dozer traveling at any significant speed down steep slopes to minimize the chance of losing control. Loss of control can result in the machine rolling down the slope.

19. Side hill travel should be avoided whenever possible. Travel up and down the slope to avoid tipping over. However if the hill travel is absolutely necessary, the possibility of rolling over can be
reduced by securely attaching the machine (using a wire rope) to another sufficiently large machine stationed at the top of the hill and properly stabilized.

Clearing operations

20. Machine operators should ensure that all workers are standing clear before pushing over trees, bulldozing rocks and rolling logs. During clearing operation, operators should take care to keep tree trunks rolling parallel to each other, especially when stacking cleared trees. Small green trees 3 to 6 inches in diameter can bend and then spring loose with great force. This force can cause injury to operators or nearby ground workers.

21. Operators pushing over large trees should recognize dead limbs or dead tops as definite hazards. Abrupt contact with the butt of a tree can crack or break off a limb that can drop on top of a machine or personnel nearby. The roots of such trees should be used to pull over large dead trees. (It should be determined in advance that a falling tree will clear the machine and operator.)

22. In clearing operations, operators should expect the greatest danger to occur from falling limbs or timber. In general excavation work, operators should be alert to dangers from overhanging dirt and rocks. In such cases, machines should be equipped with FOPS that comply with applicable requirements to protect operators.

Towed equipment

23. When operators hook a tractor to towed equipment, they should make certain that all personnel are standing clear before backing to couple up. If a ground worker is assisting, operators should not move the machine until signaled by the worker.

24. The towing machine should be stopped, the shift levers placed in neutral and the brakes set before any workers are allowed to couple the towed equipment. Wheels of equipment being coupled should be chocked.

25. All equipment being towed should be secured by a safety chain or other equivalent means in addition to the regular hitch or drawbar.

Scraper operations

26. When operating a self-propelled scraper or towing a scraper from job to job, the bowl should be secured in the up position using the scraper bowl latches or other equivalent means to provide maximum clearance for road projection such as often occurs at crossings. Scraper operators, when they are loading with the assistance of a push tractor, should coordinate their efforts with those of the tractor operator.

Traffic control

27. Machines should be kept to the right side of roadways with public traffic when traveling or working. In urgent cases where working against traffic flow is necessary, extra precautions (flags, barricades, flashing lights and traffic control persons) should be used to alert traffic.

28. When a machine is traveling or working on public roads at speeds up to 25 mph, a slow moving vehicle emblem (a triangle with point up) made of reflective material, or other equivalent devices, should be displayed at the rear of the machine.

29. Operating rules on the job will govern traffic on the haul roads and job roadways. On most jobs, the rule is to give loaded equipment the right-of-way. Traffic signs should be posted to clearly indicate the operating rules and traffic patterns. All personnel should be instructed in observance of the jobsite traffic rules.

30. Stop signs should be placed, as needed, to govern entry of light trucks, pickup trucks, cars, and other equipment into haul roads and operating areas.

31. When driving on public roads, place warning flags and/or luminous or reflective markers at
the ends of the projecting blades or other similar components that extend beyond the edges of the machine.

32. Where operations are extensive, traffic control persons also should be stationed where they are visible to oncoming traffic for at least 500 feet. Where possible, it is advisable to detour all traffic by way of another road around the worksite.

33. Operators should not stop or turn road equipment on a curve or at the crest of a hill, unless they can clearly see approaching traffic for at least 1,000 feet. Traffic control persons should be stationed on the road at both ends of the turning operation to warn approaching traffic.

34. Where machines are operating in close quarters, adjacent to excavations, buildings, other equipment or near workers, a signal person should be provided. Note: Applicable motor vehicle codes for public highways may have specified requirements other than those recommended in this document and will take precedence.

35. During nighttime operations, adequate illumination should be provided by headlights, general job lighting or both.

36. Job roads and “haul roads” should be treated to control any dust.

37. Service, supply and other auxiliary vehicles should only travel over predetermined routes to avoid collisions with heavy operating equipment. Crisscrossing by auxiliary vehicles should be prohibited.

Machine maintenance

38. Machines must be properly maintained for safe operation in the conditions encountered. Maintenance procedures should include the following:

- Make daily inspection of engines, chassis, blades, brakes, drives, hydraulic mechanisms, transmissions and other vital parts.
- Make daily visual inspections for loose bolts, fluid and air leaks, structural cracks, broken steps and handhold and other similar items.
- Make at least monthly inspections of steering linkage and, if possible, daily visual inspection by a mechanic.
- Test brakes, steering and other operational controls before beginning operations.
- The cab’s ventilation system shall be properly maintained.
- Cab glazing and mirrors shall be cleaned and broken items replaced as necessary to ensure adequate operating vision.
- Cabs shall be kept free of loose items, such as tools and debris, and all such items deemed necessary shall be securely stowed.
• A machine should be serviced on a regular schedule. (When operators leave their machines for servicing, they should make certain that the shift levers are in neutral and any locks are applied, the parking brake is set, and tools, such as a dozer or bucket, are lowered to the ground or to a secure position. If equipment must be serviced in the raised position, it must be properly blocked with timbers or equivalent means before doing any service work.

• Machine lights should be checked to ensure all are working properly after dark. Poor light can cause hazards to operators and workers and possible damage to equipment.

• Whenever cutting edges are being serviced or replaced on components that must be raised off the ground to do the work, such as scraper bowls and dozers, the component is lifted to the desired height. Place suitable blocks under its bottom near the cutting edges and lower it onto the blocks. Raise the apron arms on scraper bowls and place blocks under each arm, wedging them firmly in place by lowering the apron arms onto the blocks. Other means are acceptable when providing equivalent protection.

• Workers doing scraper bowl repair work should use extreme care when working inside the bowl. The ejector must be blocked properly to prevent it from moving in case the ejector control is accidentally actuated. A “Do Not Operate” or similar warning tag must be placed on the steering control.

• Before repairs are made on earthmoving equipment, a mechanic should make certain the equipment is shut down and secured so any system that could create a hazard cannot be activated without the approval of the mechanic. A “Do Not Operate” or equivalent sign is to be placed at the control for any system that, if operated, could cause a hazard to the mechanic.

• Workers should be equipped with a sufficient length of inflation hose between the clip-on chuck and an in-line valve with a pressure gauge or a presser regulator to permit the worker to stand in line with the tire tread or behind a suitable barrier while inflating tires.

• Before re-inflating a tire, the wheel and tire assembly shall be placed in a tire-restraining device.

• Steps, ladders, walkways and platforms should be kept free of grease, oil, ice and mud. Handholds should be provided on all equipment to aid operators in climbing on and off vehicles.

• During refueling operations, all personnel in the vicinity should stop all engines and refrain from smoking. During refueling, no work shall be done near refueling machines that could start a fire, such as welding or using machinery that creates electric sparks.

Machine storage

39. When equipment is stored indoors, overnight or for maintenance purposes, it should be kept away from flammable materials, welding operations and heating units. Storage buildings should be provided with proper fire extinguishing equipment.

Sources of information

National Safety Council, 1121 Spring Lake Drive, Itasca, IL 60143.

Industrial Data Sheets: Barricades and warning devices for highway construction work, 239.

Tractor Operation and Rollover Protective Structures, 622.

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