

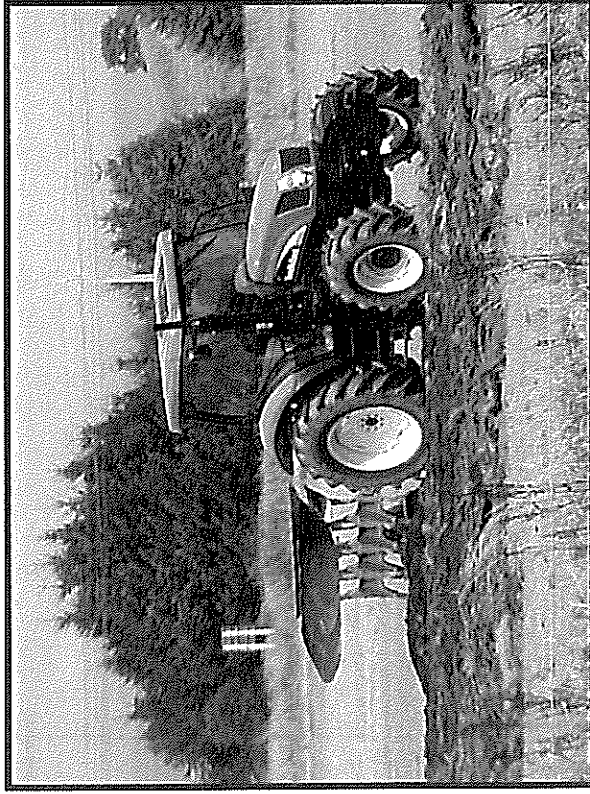
Agribusiness
TRAINING



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TRACTOR SAFETY SKILLS TRAINING



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Study Notes

Unit Standard

19014

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Agribusiness Training Ltd and CB Norwood Distributors Ltd thank the Accident Compensation Commission and Mr. David Henshaw for their kind permission in allowing us to incorporate their material into this tractor safety booklet. Agribusiness Training Ltd wishes to acknowledge the contribution made by Mr. William Atkinson to the contents of this booklet.

1. The Law

New Zealand Law on Tractors

- Children must be 12 years old in order to be allowed to drive an agricultural tractor (even on a farm).
- No employee under the age of 15 years may drive a tractor.
- It is illegal for a child under 12 years of age to ride on a tractor "while it is drawing any implement". However, it is legal (although not advisable) for a child under 12 to ride on a bare tractor (i.e. with no implement attached).
- It is legal for a 15-year-old to drive a tractor on a public road provided they hold a motor car or special vehicle licence.
- You must have a current driver's licence to drive any tractor on a public road. A Class 1 licence allows you to drive a tractor with a gross laden weight of less than 4500 kg. A Class 2 to 5 or heavy traffic licence is required for tractors with a gross laden weight of more than 4500 kg. Note: Gross laden weight is the total weight of the tractor plus its load.
- The legal definition of a public road is any place where the public have free uncontrolled access. This includes a tanker track or any part of the farm where the public can travel freely. It may be that a simple "Private Property" sign or a closed gate is enough to change it to a controlled area.
- It is illegal for a child under the age of 15 to drive any tractor (e.g. industrial tractor) other than an agricultural tractor.
- It is illegal for a child under 12 to ride on an agricultural implement drawn by a tractor unless that implement is "a sled or trailer designed or adapted exclusively or principally for the carriage of passengers or of goods". The act does not specify whether a transport tray would be regarded as an "implement drawn by a tractor" or as "a sled or trailer designed for the carriage of passengers or goods". Having a child stand on the footplate beside the driver (even when a tractor is not "drawing" an implement) can be dangerous. If you are forced to suddenly brake, the child can be catapulted forwards off the tractor and may be injured in the fall.
- OSH regards a transport tray as an implement and, therefore, it may be illegal for children to ride on.

Registration

- Tractors must have the appropriate registration to be on the road. The requirements are different depending on the size, use and on-road speed capability. Most tractors used in agricultural operations, including self-propelled grass mowers, fit under the "Exempt Class B" category of Agriculture. Trailers and implements (being towed on a public road by an "EB" registered tractor) do not need to be registered. Tractors registered as "G" require trailers and implements to be registered for road travel.

Warrant of Fitness

- The law requires that a tractor is maintained in a road-worthy condition if it is driven on the road. A tractor that is to be driven on the road at speeds above 30km/hr must have a WOF.

- In most cases drivers of tractors are not required to fill out log books.

Over-dimension Vehicles and Loads

A tractor or implement that is wider than 2.5 metres is classed as an over-dimension vehicle. The law regarding over-dimension vehicles is quite detailed but, for most tractors, the basic requirements are:

- During daylight hours you must travel with your headlights on low beam and display a flashing amber light if you are wider than 3.7 metres.
- During the hours of darkness all tractors must be clearly visible from at least 200 metres (in clear weather), display a flashing amber light (must be visible and, therefore, is normally mounted on the roof of the cab), display a clear or amber light to the front and a red light to the back, and retro-reflective yellow-green panels at the outer extremities of the vehicle.

2. Tractor Maintenance

Daily Maintenance

- It is highly desirable that this check is used at the beginning of each day. It should also be used each time there is a change of operator. This will help ensure each person is responsible for the tractor's condition during the time they are operating it.

W - Water:

- (a) Water should be checked in the cooling system. The level should be at the manufacturer's specification. Other components of the cooling system that should also be checked include hoses (for damage and wear), radiator (for damage, leaks or straw) and the fan belt.
- (b) Ballast water should be placed in the tyres. Check that it was replaced the last time a puncture was repaired.
- (c) Consider the battery water, especially in hot weather, and keep the electrolyte at specified levels.

O - Oil:

- (a) Engine oil filled to specified levels.
- (b) Gear box and transmission oil filled to specified levels.
- (c) Power steering filled with correct grade of fluid to specified level.
- (d) Hydraulic system reservoir filled to specified level.

G - Grease:

- (a) All grease points specified for daily application should be greased.

A - Air:

- (a) The air pressure in the tyres should be visually inspected (i.e. any semi-flat tyres). Since tyre valves leak, the actual pressure usually only needs to be checked during a scheduled service.
- (b) The engine air cleaner needs to be considered depending on the previous day's work. If it has been extremely dusty then the pre-cleaner (if fitted) will need to be emptied. Also, either the oil bath will need to be emptied, cleaned and fresh oil added, or the paper filter element will need to be cleaned as specified.
- (c) Any cab air conditioning filters will also need the same considerations as the engine air filter.

F - Fuel:

- (a) Diesel engines may require special "bleeding" procedures if they run out of fuel. To avoid this, each day should start with a full tank of fuel. Water in the fuel is also highly undesirable. If a fuel tank is left empty at the end of the day, significant water may condense on the walls of the tank as the air in the tank cools. This water collects at the bottom of the tank and can move on into the fuel system, overloading filters and damaging other components. A common approach to prevent this requires the tractor to be refuelled at the end of the day. Refuelling at this time expels the warm moisture-laden air from the tank before condensation in the tank begins.

S - Safety:

- (a) Check around and on the machine and remove objects, animals and people (especially children).
- (b) Check for any tyre damage.
- (c) Check for any water, fuel or oil leaks.
- (d) Check that cowlings and accessories are not damaged or loose-fitting and are correctly latched.
- (e) When an implement is already attached, check that all lynch pins are in place and all other connections (PTO, hydraulic, electrical) are complete and secure. Check that 3-point linkage adjustments are correct.

Planned Maintenance Programme

- Both the owner and the operator are responsible for maintaining the tractor in a safe operating condition.
- It is standard practice to have tractors serviced by a trained mechanic at least once a year or every 200 to 300 hours of use. These services should include checks on steering, brakes, hydraulics and controls, chassis and frame bolts as well as changes of oil and filters as required by the manufacturer's specifications.
- Tractor hydraulic and air conditioning systems operate under extreme pressure so, when checking for leaks, use gloves or the correct tools. Do not use your hands as escaping fluid can penetrate the skin, causing serious injury.
- The transmission oil in tractors with oil clutches (i.e. power shuttle transmissions) should be checked regularly and the level should be constantly topped up to the maximum as, when driving down steep slopes, the hydraulic pump can suck in air causing the transmission to disengage the drive. This could be very dangerous in certain situations.
- Tractor cooling systems operate under pressure which is controlled by the expansion tank cap. It is dangerous to remove the cap while the system is hot. Always turn the cap slowly to the first stop and allow the pressure to escape before removing the cap entirely. Never remove the cap from the top of the radiator unless the expansion tank pressure cap has first been removed.
- The owner's manual for most tractors will have safety tips relevant to that model. Often people read the manual after something goes wrong. Many tractor accidents occur as a result of insufficient routine maintenance, particularly the adjustment of hand and foot brakes. It is also a good idea to keep warning and safety details clean and readable.
- Tractor radiators are more likely than car radiators to become blocked and then overheat due to the presence of thistle-down, straw, starling nests, etc.

- Starlings have a habit of nesting on top of engines (especially next to turbochargers) that, if not removed, will cause a fire under the bonnet.

3. Controls

- The most important control on a diesel engine is the stop control. Different tractors have different stop control mechanisms for stopping the engine:
 - (a) the stop control is pushed in,
 - (b) the stop control is pulled out,
 - (c) with the throttle movement, or
 - (d) with a keyThese differences can be confusing and dangerous in an emergency if you are operating an unfamiliar tractor. Learn and practice the emergency engine stop for your tractor.
- Most hand and foot controls on tractors require much more precise and controlled movement in one direction than the other. For example, throttle opening (increasing speed), brakes being applied and clutch being engaged all require more control for safe operation than when the throttle is shut down, the brakes released, or the clutch is disengaged.
- Your hands, arms, legs and feet are much stronger and more controllable in one direction than the other. For example, closing the hand, bending the elbow towards you and pushing your legs and feet away from you are all stronger and more easily controlled actions than the reverse movements.
- Most (though, sadly, not all) hand and foot controls on tractors are designed so that when precise control is needed this coincides with the movement of the human body over which you have most control. The one exception is the foot clutch, which is why engaging the clutch smoothly is always the most difficult task to master for a learner driver. It requires precise control to engage but, in fact, the foot is moving in the wrong direction (towards you) to achieve this.
- When a tractor engine stops, the power steering becomes inoperative. This makes it very difficult to steer when, for example, free-wheeling down a hill.
- The correct way to hold the steering wheel (especially on older model tractors) is with your thumbs positioned on the outside of the wheel. Where the driver is driving an older model tractor with wet, slippery hands or where the tractor has power-assisted steering, hands should be positioned with the thumbs inside the steering wheel to provide maximum control. Drivers must be aware of the potential for injury to fingers/thumbs from "feedback" when the front wheels of tractors without power-steering strike an object.
- Steering knobs on steering wheels may make reversing easy but they are also likely to catch on the cuff of a coat and interfere with normal steering, resulting in a loss of control.

4. Tractor Design

Safety Starts

- Most modern tractors have safety starts but they do not all work the same way. Most require at least one gear lever to be in neutral. Some require the clutch to be depressed. Some require both. Caution must be used where the clutch needs to be depressed but the tractor can still be in gear.
- Some tractors are designed so that the safety start mechanism is by-passed if jumper leads are connected directly to the terminals of the starter motor. Be aware that they can start in gear.
- Only start a tractor when sitting in the operator's seat.

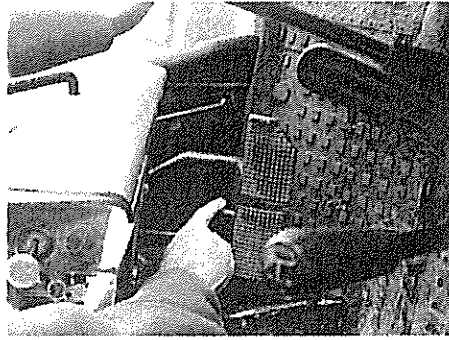
Transmissions

- With some power-shift transmissions, which give a high-low option in each gear, one of the ratios will allow the tractor to free-wheel without engine braking. Before going down a hill make sure you engage the option that has engine braking.
- Most shift-on-the-move gear systems are safer than conventional manual-shift boxes because the gears remain engaged during changing. In other words, you do not have to go through neutral each time you change, which would expose you to missing the change (which would be dangerous on a hill). Hydrostatic transmissions operate in the same manner as shift-on-the-move systems and are also safe.
- Some tractors fitted with forward and reverse shuttle transmissions will engage the drive if the forward-reverse shift lever is shifted into gear, even without the clutch being depressed, so care is needed to avoid accidental contact with the gear shift levers when the engine is running.

5. Brakes

Wheel Brakes

- Releasing the steering wheel of a tractor with unevenly worn or maladjusted rear brakes will cause the tractor to pull itself around to full lock in 10m or less if one brake engages preferentially to the other. (This often occurs when footbrakes are not locked together.)
- For on-road use, drivers should lock the brake pedals together to avoid uneven braking. However, sometimes individual wheel brakes are not adjusted uniformly. In an emergency, unevenly adjusted brakes can cause loss of control, particularly when travelling at speed. Hydraulic braking systems often use equalisers, which help to eliminate this problem.
- It is good practice to apply the hand brake (or lock the foot brake) on a tractor before dismounting as many people have been injured through failing to do so.
- Most modern tractors will engage 4-wheel-drive automatically when both brake pedals



are depressed. This gives you 4-wheel-braking, which is useful when braking on slippery surfaces.

Engine Braking

- When travelling down a hill on a tractor it is always preferable to use engine braking (and even an exhaust brake, such as those in trucks, if one is fitted to your tractor) than to use the foot or hand brakes. A very high level of skill is needed to use foot brakes safely, so always engage a low enough gear at the top of the hill to provide effective engine braking with the throttle right back but not so low a gear that it resists the momentum of the tractor and causes it to start sliding.
- When using engine braking down a hill, if the throttle (governor control) is shut off too quickly this may induce a slide.

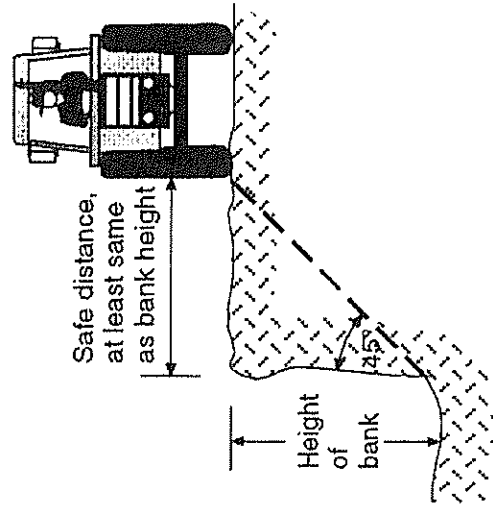
6. Terrain

Gear Changing

- In many older model tractors, it is very difficult to change gear while the vehicle is moving. When approaching a hill, the safest option is to select a gear low enough to allow the tractor to negotiate the whole hill without any further gear changes.
- A hill should be descended in the same gear that is used to ascend it.
- Select a gear low enough to provide sufficient engine braking, thereby avoiding the need to use the foot brakes.
- With power-shift transmissions, changing to a slower gear while descending a hill may induce a slide because the instant deceleration is similar to braking. Select the appropriate gear before descending the hill, just as with conventional transmissions.
- Suddenly releasing the clutch when changing gear while ascending a hill may cause the tractor to flip over backwards.

The Terrain Tractors Operate On

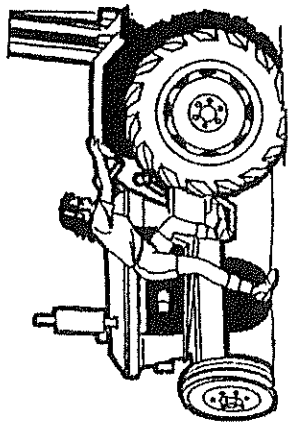
- Excessive speed can cause a tractor to roll over, even on flat terrain. Roll-over can also occur on rough ground while travelling in a straight line.
- Many accidents occur while travelling home (ferrying) after operating on relatively steep terrain all day. The operator often loses concentration after leaving the "high risk" steep ground only to drive off a track or into a ditch on more level terrain.



- Fatigue, drugs or alcohol affect a driver's ability to operate a tractor. The risk of an accident is increased on steep terrain due to slower reaction times and/or impaired judgement.
- Keep clear of ditch and river bank edges. As a guide, the depth of the ditch will indicate the safe minimum distance from the bank. When approaching ditches and banks look ahead rather than back at your implements. Give yourself plenty of room for turning and watch for holes, gullies and washouts that could put the tractor in an unstable position.

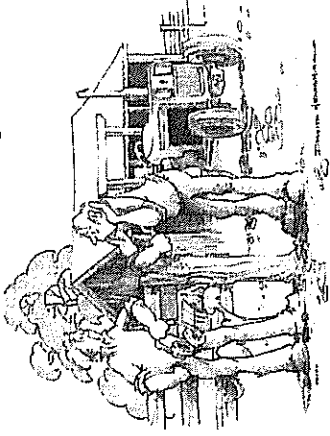
7. Driving Habits and Safety Frames/ROPS

- **Operating**
 - Only start a tractor when sitting in the operator's seat.
 - Always check that all the hydraulic controls are in the down position, the PTO is disengaged, gear levels are all in neutral and the parking brake is engaged before starting the engine.
 - Numerous fatalities have occurred from mounting onto or dismounting from a moving tractor.
 - Minor injuries (from barked shins to broken legs) commonly occur during mounting and dismounting. The correct dismounting method is to back down the steps in the exact opposite motion to mounting. Also ensure the steps are free of mud and debris to prevent slipping or tripping. Most tractors are designed for safe operator access on the left-hand side only. This usually prevents accidental contact with brake pedals and hydraulic controls. Dismounting from the right-hand side could expose the operator to injury from implements mounted and off-set on the right-hand side (e.g. mowers).
 - Tractors should be mounted /dismounted on the left-hand side.
- The majority of tractor accidents occur while travelling to or from the job (ferrying). A much smaller percentage actually occurs on the job.
- Excessive speed while travelling over rough ground is a common cause of tractor accidents and can result in the driver or, more likely, passengers being thrown off.
- One of the most common causes of child fatalities with tractors is backing over a child who is playing on the ground.
- Always ensure there is adequate ventilation when operating tractors in confined areas, such as a hay barn or workshop as the exhaust emissions from a tractor can be lethal.
- Turning corners with a rear mounted implement causes the implement to swing out to the opposite side. If you move too close to a fence with the implement, swing slightly in towards the fence, stop then reverse out rather than swing abruptly away from the fence.



- Many accidents occur because smooth control of foot pedals is lost. Foot accelerators are particularly difficult to control over bumps. Ensure the seat is adjusted to a comfortable position so that you can apply consistent pressure with your foot and you can "ride out" the bumps.

- One of the most likely ways to break (or, at least, sprain) a thumb is to turn your hand upside down to grip the top inside of the steering wheel instead of using the more normal grip on the outside. Power-steering can provide some protection if this practice is used but control over the tractor is reduced because, at best, you can only swing the wheel 180° without twisting your arm.



"I said...sex makes y'go deaf too!"

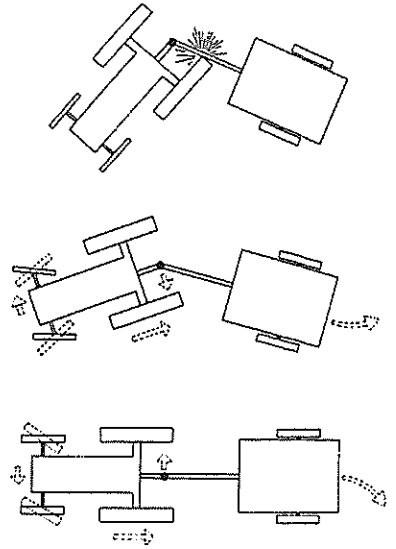
- It is good practice to monitor what is happening behind you when driving a tractor. However, it is almost impossible to maintain a straight line while you are looking over your shoulder. Momentarily taking one hand off the steering wheel will help avoid making an involuntary turn with the tractor. If turning to the right, take the right hand off and shift the left hand to the 12-o' clock position.

- Many people have suffered severe injury to their heels while riding on the drawbar of a tractor pulling an implement. When the tractor takes a corner, the two drawbars act like a pair of a high-powered scissors. Do not ride on the drawbar of a tractor. **Never allow passengers to ride on tractor or implement drawbars.**

- Long exposure to tractor engine noise can lead to impaired hearing. Higher pitches, such as telephones, become difficult to hear. **Always wear approved ear muffs when operating tractors that are not fitted with noise-reducing cabs.**

- Rear-view mirrors can reduce driver fatigue since it allows the driver to observe an implement or vehicle behind the tractor.

- Reversing:



Safety Frames/ROPS

- Safety Frames are also called Roll-over Protection Structures (ROPS).
- The approved Code of Practice for ROPS on Tractors in Agriculture Operations came into force after 31st August 2001.
- Tractors accounted for approximately half of all accidents on farms in New Zealand. After the introduction of safety frames, tractor accidents fell to one-third of all accidents.
- Many injuries sustained from roll-overs with tractors equipped with safety frames have been the result of the frame itself striking the driver as they tried to climb off.
- If a tractor with a safety frame is about to overturn, it is safer to hold tightly onto the steering wheel than to attempt climbing off unless it is obvious that you face a large drop.
- If a tractor without a safety frame is about to overturn, jumping off uphill is advisable only in the very early stages. If you make a late decision to jump (which is normal), use a downhill side and run quickly across the slope. Attempting to jump off the uphill side will be like being on a treadmill and the tractor may roll faster than you can climb it, thereby trapping you as it rolls.
- When a Roll-Over Protective Structure is fitted to any tractor the structure must comply in all respects with an approved performance standard or code. This includes all frames approved under the repealed provisions of the Machinery Act 1950. A register of acceptable performance standards for ROPS is maintained by the Occupational Safety and Health Service.
- No one should use (or allow the use) of a non-exempt tractor that has had the safety frame removed. This should apply regardless of whether you own the tractor or drive for someone else.
- All agricultural tractors, except those excluded below, should be fitted with a roll-over protective structure that meets the relevant design and manufacturing standards. This applies to all tractors used in agricultural operations (both tracked and wheeled) that have been purchased new after 1 September 1970, with the following exclusions:
 - for tractors purchased new on or before 31 August 2001, crawler tractors, and wheeled tractors weighing under 762 kg or more than 4000 kg;
 - for tractors purchased new after 31 August 2001, tractors weighing under 700 kg;
 - tractors used in the following operations:
 - (a) operations connected with any orchard, hop garden, blueberry garden or greenhouse;
 - (b) operations in any vineyard carried out beneath vines supported overhead;
 - (c) operations in or adjacent to any building or structure used in the keeping and care of poultry for pecuniary gain.

Where it is considered that it is not practicable to fit a roll-over protective structure to an agricultural tractor due to the nature of the operation, application may be made to:

The General Manager
Occupational Safety and Health Service
PO Box 3705
Wellington

for a notice in writing excluding tractors used in such operations from the requirements of this code of practice.

Where a tractor which is excluded from the requirement under this code to fit a ROPS is transferred to an operation requiring a ROPS to be fitted, a responsibility exists to ensure the tractor has the appropriate roll-over protective structure before the tractor is used in that operation. This would be a "practicable step" to ensure the risk of injury or death resulting from a tractor roll-over is minimised.

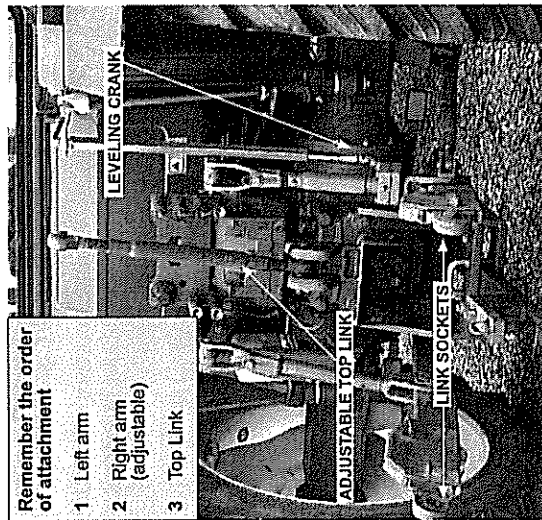
Under Clause 67 of the Health and Safety in Employment Regulations (Duties of manufacturers and suppliers of plant) there is also a responsibility on the supplier to ensure that the tractor, if used for the purpose for which it was designed, is "manufactured so that the likelihood that the plant will be a cause or source of harm is minimised as far as practicable". This would include ensuring that a tractor being sold is fitted with a roll-over protective structure of the appropriate standard unless the tractor is excluded under this code from the requirement to be fitted with a roll-over protective structure.

- Under the Code of Practice, you cannot modify (cut, weld, drill, put in a hinged joint, or straighten) an approved safety frame on a tractor. This includes welding additional brackets on the frame since this can weaken the structural design.
- Where a safety frame becomes substantially damaged (or corroded), the Code strongly discourages its continued use or getting it repaired. It is also illegal and dangerous to repair the frame. The frame must be replaced with another that is undamaged and has been approved.
- The code states that seat belts should be fitted on new tractors in New Zealand. They can (a) prevent you being thrown off, even when the tractor is bouncing but not in danger of overturning, and (b) where the tractor is fitted with a safety frame, prevent you from attempting to climb off when you feel an overturn is imminent.
- The majority of tractor roll-overs in New Zealand involve the tractor tipping sideways by 90° – that is, rolling onto its side. Remaining in the seat (either voluntarily or by a seat belt) of a tractor fitted with a safety frame would prevent injury in most cases.
- Wearing a seat belt on a tractor increases the operator's safety and sense of security when operating on steep and/or rough ground, allowing them to maintain better control of the tractor.

8. Linkages and Hitching

Operating Tractor Hydraulics

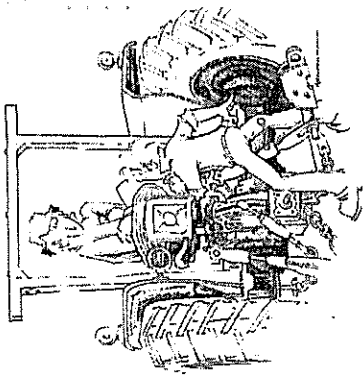
- Many tractor accidents have occurred when the operator has leaned over from the rear of the tractor to adjust the height of the lift arms and been caught by the rising linkages. **The hydraulic control levers should only be operated from the operator's seat.**
- When attaching an implement, do not operate the tractor hydraulics to align the links with their holes or pins while standing at the rear of the tractor. Do not use fingers to align holes with mounting pins. Many people have lost their fingers doing this. Use the screw adjustment on the right hand lower link and top link instead. If the top link is frozen or bent, it should be replaced with a new one; a new replacement is inexpensive to purchase. Use the hydraulics to align the left hand lower link but only while still seated on the tractor.
- Tractor hydraulics will allow implements (both front and rear) to drop rapidly even when the engine is not running. **Always lower the hydraulics when the tractor is left unattended.**
- Hydraulic control levers may not always be in the position you left them when you stopped the tractor. Children or other operators may have moved the lever with the result that an implement may move unexpectedly upon starting the tractor. **Always check that the levers are in the down position prior to starting the engine.**



- Tractor manufacturers have not yet standardised hydraulic controls. A forward movement of the position control lever may either raise or lower the linkage arms, depending on the make of tractor. **Know your tractor!**
- Climbing under an implement that is supported only by the tractor hydraulics is extremely dangerous. Component failure within the hydraulic system at that moment is unlikely but possible. It is more likely that another operator or a child may move the control lever to the lower position without your knowledge. Always use a mechanical support as a back-up.

Attaching Implements to Tractors

- The correct procedure for attaching three-point-linkage implements is to attach the left-hand lower link first followed by the right-hand lower link and then the top link.



"Pull that lever and stand where you're standing lad... an' I'll name th' new gelding after you!"

- It is often necessary to stand between the tractor and the implement when attaching the three-point-linkage, particularly when the implement is power-take-off (PTO)-driven. In these cases, extreme care is required. Always stop the tractor engine before attaching or adjusting a PTO shaft.
- Check chains or stabiliser bars are provided to limit sideways movement of three-point-linkage mounted implements. Unless the implement being used specifically requires some lateral movement (e.g. a mouldboard plough), the check chains should always be tightened or stabilizer bars put in place.
- The size of the pins on implements and the balls in the linkage arms on tractors are standardized into three categories. It is important that implement and tractor categories are correctly matched, otherwise excessive movement of the connection will occur and increase wear and/or damage; this could result in the implement detaching unexpectedly.

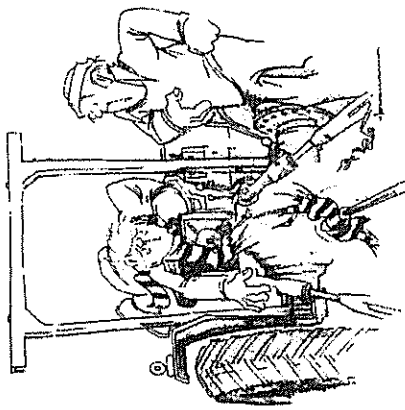
Hitching Height

- The likelihood of the tractor tipping over backwards increases according to where a load is hitched to the rear of the tractor. The higher the load is hitched, the greater the risk of tipping.
- **Note: The top link hole must never be used as a pulling hitch point.**
- It is a myth that pulling from a point below the rear axle of a tractor will not flip it over backwards.

9. Power-take-off Shafts

Shafts

- A PTO shaft rotating at 540 rpm can entangle a piece of clothing in less than 1/4 of a second (540 rpm = 9 revs/second).
- A bare PTO shaft rotating at 540 rpm has a peripheral speed of one metre per second. That means that if you were sitting on the tractor seat, which is about a metre above the PTO shaft, and your clothing hung down and became entangled in the PTO shaft, it would take one second to drag you off the seat onto the shaft.
- **You should never leave the tractor seat without disengaging the power-take-off drive.**
- **You should never make any adjustments to PTO powered implements without first disengaging the PTO and stopping the tractor engine.**
- Wearing loose clothing (such as oilskin raincoats) while operating tractors and PTO powered equipment is extremely hazardous, unless extra care is taken by the operator and all guards are in place.



"Well th' good news is y'not still wearin' that end!"

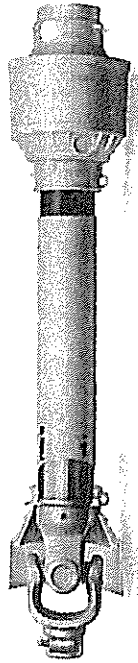
- PTO power equipment is normally designed to operate at two standard speeds (540 rpm and 1000 rpm). Equipment designed to operate at 540 rpm is normally fitted with a 6-spline female PTO shaft. Equipment designed to operate at 1000 rpm is normally fitted with a 21-spline female PTO shaft.

- Some modern tractor PTOs can operate at 750 rpm, sometimes called 540E (economy). It is important that PTO powered implements are operated at the speed for which they were designed, otherwise they can literally fly apart at the greater speed.

- Unguarded universal joints and shafts on a PTO drive are extremely dangerous. **Always ensure that the PTO shaft guard is in place.**

- Tractor PTO stub-shaft guards that are hinged or pinned (with a lynch pin) are more likely to be replaced after attaching an implement than those that are bolted. This is mainly because tools are not required to attach or detach them.

- Guards on the PTO shafts of tractors are designed to prevent loose clothing becoming caught in the shaft. They also protect the shaft from rust.



- **When the tractor PTO is not in use, the PTO stub-shaft cover should always be fitted.**

- With some older PTO shafts, it is possible to fit the two halves of the shaft together incorrectly. The correct way to fit this part of the universal joint (which is welded to the end of one of these shafts) is to line it up with its counterpart on the other shaft when you slide the two shafts together. If they are incorrectly fitted they will be at right angles to one another, causing excessive vibration and possible breakage.

- If the two halves of a universal-joint drive shaft come apart (such as when an implement is lifted too high), the shafts do not just stop turning. The tractor end of the shaft will flap about dangerously. Before engaging the PTO drive for an implement you are using for the first time, lift it or turn with it to the maximum and check the PTO shaft does not slide apart.

- Sliding PTO shafts must be greased regularly to prevent damage from binding or locking.

PTO Clutches

- Independent PTO clutches can be dangerous. When moving off using a foot clutch, drivers get into the habit of watching out for other people. With a hand-operated independent PTO clutch, drivers can often be inattentive when engaging the clutch as it does not involve the tractor moving off.

- Relying on a hand-operated independent PTO clutch to keep a PTO machine out of drive can be dangerous. Many are spring-loaded to engage. Even although they have safety locks, the teeth on these become worn. It is better to put the PTO out of gear if it is to be disengaged for any length of time.

- Two-stage clutches ("live drive") often result in the PTO engaging suddenly and without warning, especially with inexperienced drivers. Apart from damaging the machine and drive, it is also dangerous. Always keep people clear when engaging PTO-driven equipment.

- Independent PTO systems on tractors can easily be engaged inadvertently. Keep the tractor PTO stub-shaft covered when not in use and turn the engine off when adjusting or unblocking PTO power implements.

10. Implements

- Implements that are towed by or hitched to the tractor create their own hazards. It is advisable to read the user manual (if available) before operating any new equipment.

- ALL the safety guards must be fitted to any PTO-powered implement. For example, the blades on a disc mower spin at 300 km per hour and will cause serious harm or death to anything that gets in its path.

- When operating PTO equipment, care should be taken not to lift the implement too high as this can cause the PTO shaft to operate at an extreme angle. This damages the universal joints and can cause the shaft to come apart and rotate uncontrollably. This also applies when turning sharp corners with trailed PTO equipment such as a hay baler.

- Never stand under or in any hydraulically operated equipment such as a lifted trailer hoist or baler tailgate without the appropriate safety stops in place.

- When servicing or checking an implement such as a baler, ensure the machine's internal mechanism cannot move. The plunger can shift suddenly if the crankshaft rocks over the top dead centre. Most balers have a flywheel brake so make use of it.

- Liquids moving around in a tank (e.g. a half full spray tank being driven on the side of a slope) can suddenly affect the stability of a tractor.

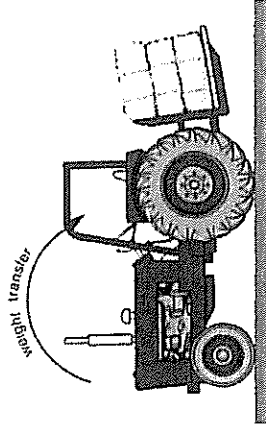
- Some implements like a mounted plough can cause major tractor instability when lifted out of the ground at sloping headlands. Care should also be taken when changing over reversible ploughs at headlands.

- When reversing a trailed implement, turn the steering wheel the opposite way from the direction you require the trailer to turn.

- When towing heavy loads down a slope, be aware that if you turn across the slope your load may push the rear of the tractor and cause the trailer to jack-knife.

- When using implements that require the tractor to be stationary with the engine running, put the gear and range levers in neutral, apply the handbrake and use suitable wheel chocks.

- Add rear ballast when using lifting equipment fitted to the front of the tractor.

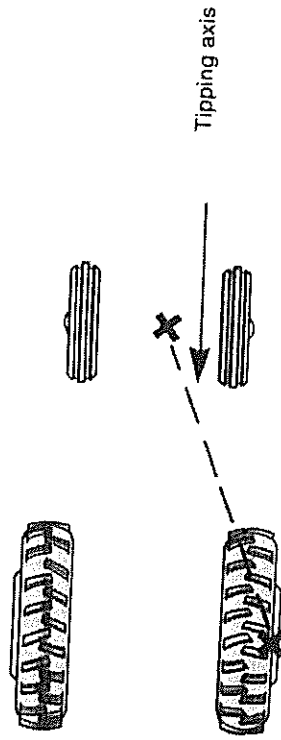


11. Driving on Slopes

- A rear-mounted load has a similar effect to a slope. Carrying a heavy load on the tractor rear linkages reduces front end weight and transfers it onto the rear wheels.
 - (a) the front wheels may leave the ground so there is no steering.
 - (b) keep the rear-mounted load as close to the ground as possible so that, if rearing does occur, little momentum develops and it is less likely the rearing forces will break the linkage arms.
- The relationship between speed, angle of slope and cornering is quite complex. The safest course when driving on slopes is to drive slowly thereby minimising the detrimental effect of speed.
- Maximum lateral stability of a tractor occurs when the rear end of the tractor slips downhill a little as the tractor travels crabwise across a slope. The first time this happens, the driver may feel panicky but relief follows as they realise that the crabwise stance uphill wheel brake pedal is better. Experienced hill-country operators often lightly touch the causing the tractor to travel crabwise on a slope. This is not recommended for inexperienced drivers but, nonetheless, is a safe practice for experienced drivers.
- Turning a tractor sharply uphill (through 90°) when travelling slowly across a steep slope may prevent a sideways roll-over but increases the risk of a rearwards flip-over, particularly on soft soils (e.g. sand). It is better to edge uphill gradually than to turn sharply uphill.
- Turning a tractor sharply downhill (through 90°) when travelling slowly across a steep slope increases the risk of a roll-over (as the tipping axis becomes parallel to the slope part-way through the turn) and a loss of control due to a slide induced by loss of traction in the downhill position.
- Widening the rear wheel track increases the stability of a tractor. When operating on slopes, this is usually a safer course of action than fitting dual wheels.

Turning Uphill or Downhill

- Is it safer to turn uphill or downhill when travelling across a slope? **Either answer is correct but only in particular circumstances. Unless you understand what these circumstances are, you could place yourself in grave danger by doing the wrong thing.**



Plan

Downhill slide

Firstly, it is important to realise that when turning uphill or downhill it should not be a right-angled turn but should veer off in the uphill or downhill direction. Heading straight uphill risks a rearwards flip-over, and heading straight downhill risks a loss of traction and an uncontrolled slide.

Secondly, it is important to visualise the tipping axis and the vertical line of action of the centre of gravity. When the tractor is parallel to the slope (driving across it), the tipping axis slopes slightly uphill towards the front. The tractor is most vulnerable when the tipping axis is positioned exactly parallel to the slope. Therefore, if the tipping axis is parallel to the slope, the front end of the tractor would be further downhill than the rear end since the tipping axis itself runs diagonally across the tractor.

- **On a steep slope, always turn uphill, travelling at a slow speed.** Experienced hillside operators can induce the tractor to crab across a steep hillside with the front pointing slightly uphill by lightly touching the uphill brake pedal, and tend to use this technique when cultivating. They do this for two reasons – to gain better traction and to place the tipping axis on an even greater angle uphill towards the front and therefore further away from being parallel to the slope. In doing so, even though the practice looks frightening (and is definitely not recommended for inexperienced drivers since it requires precise control over functions such as braking), it is nonetheless deliberately placing the tractor at a safer attitude to the hillside, which is desirable.
- **On a mild slope,** where the tractor might be travelling faster, a different turning technique is required. The action of turning a corner at speed can change the line of action from the centre of gravity, forcing the vertical attitude towards the outside of the corner. If travelling at speed on a hillside, it is important that any induced movement of the line of action away from the vertical be in an uphill direction where it will be opposed by gravity. If the induced movement is downhill, it will be assisted by gravity and will swing even more quickly towards the tipping axis.
- **Therefore, where appreciable speed is involved on a mild slope, always turn downhill.**
- So, whether to turn uphill or downhill all depends on how fast the tractor is travelling.
- The next obvious question is: “At what speed should you change from turning uphill to turning downhill on a slope?” There is no accurate answer to this question; the only truly safe course of action is, when in doubt, travel slowly across all hillside and turn uphill.

12. Rough Ground

- When travelling at speed across rough but level ground, relatively small bumps can propel one rear wheel of an unsprung tractor into the air with enough acceleration to simulate a steep hillside. If the driver attempts to turn a corner at the same time this can be equivalent to turning uphill at speed and can cause the tractor to roll over.
- When ferrying (i.e. travelling to or from the job rather than working with an implement), speed, bumps, inattention and “skylanking” are significant contributors to tractor fatalities.

13. Cornering

- When turning a corner with a tractor, speed has a greater destabilizing effect on the tractor than the tightness (radius) of the turn.
- **When travelling at speed across a mild slope, you should always turn downhill** (which contrasts with what you should do when travelling slowly across a steep slope).
- Turning corners at high speed on flat ground accounts for more fatalities than driving on steep slopes.

14. Differential Locks

- Differential locks are designed to lock both drive wheels together so that both must drive or brake, regardless of which wheel has more (or less) traction.
- A differential lock usually works only on the rear wheels and seldom locks the front wheels of a four-wheel-drive tractor together.
- Engagement of the differential lock also locks up the steering. Therefore, diff-locks should only be used when going straight ahead. They must not be used going across hillslides even though it helps prevent the top wheel from skidding.
- Engagement of the differential lock when a tractor is skidding while ascending a hill can sometimes suddenly produce so much extra traction that the "instantaneous" acceleration can cause the tractor to flip over backwards. This is seldom the case on flat ground.
- With many tractors, the differential lock may not automatically disengage when the pedal is released. Operators should learn (and practice) how to disengage the differential lock on the tractors they operate.

15. Traction

Facts about Traction

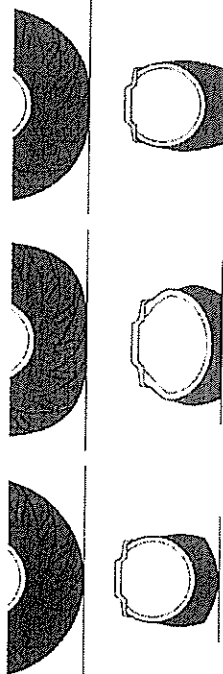
- Loss of traction is the most common contributing factor of all tractor accidents.
- Pasture on a hard, dry soil may give you less traction (especially when damp with dew) than that on a more moist soil.
- When driving a tractor forwards down a steep hill, one rear wheel may rotate backwards. This is caused by the opposite wheel having better traction. The differential allows the wheel with good traction to force the wheel with poor traction to skid then eventually rotate backwards.
- When a tractor is being driven down a steep hill and it starts to slip, take the following corrective measures:
 - **Speed up the engine** in an attempt to get the drive wheels to catch up with the forward speed then gently slow the engine down again (do not attempt to change gears unless

it is a power shift) and engage the differential lock but only if there is clearly a straight run to the bottom of the hill. Do not touch the brakes in either case.

- Using a 4-wheel-drive increases traction considerably. It is always a good idea to engage 4-wheel-drive before travelling on slippery or sloping terrain or towing heavy loads.

16. Tyres

- Tractor driving tyres inflated to different pressures will result in uneven traction. It is quite normal to have different tyre pressures between the front and rear tyres but each pair of both front and rear tyres must be inflated to the same pressure.

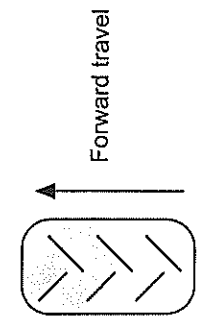


OVER INFLATION
Prevents full contact of tyre with ground. Tyre is too rigid and can be damaged by impacts shown by excessive wear at centre of tread.

UNDER INFLATION
Causes tyre to flex too much and heat up. Shows excessive wear on outer tread.

PROPER INFLATION
Provides full tread contact with ground. Shows proper traction and flex. Shows up much of too little flexing.

- Correct inflation is 80-105 kPa (12-15 psi) for treadbar driving tyres, regardless of whether they are radial or cross-ply construction. This needs to be checked more often as some tractors could have tyre pressures ranging from 8 psi up to 30 psi. Non driving front tyres need 140 kPa (20 psi).



- Ground tread print:
 - Tread bars on tractor tyres do not give as much pull in reverse compared to forward for two reasons:
 - (1) they block up with soil; and
 - (2) in reverse gear, the 2-wheel drive tractor transfers weight away from the rear driving wheels.

17. Dual Wheels

- Dual wheels do not always give you added traction, especially on hard dry land. They produce twice the footprint area but, unless the weight on the axle is doubled, penetration will be reduced. This does not matter on softer soils as it is easier to penetrate and the increased tread bar area substantially increases traction. However, on hard ground, a few tread bars penetrating the soil (even a little) can give better traction than a greater number of tread bars which may not penetrate the soil at all.
- Dual wheels provide greater lateral stability and more flotation.

18. Weight on the Driving Wheels

- Any ballast in the form of weight will increase traction, thereby improving safety. Too much ballast may increase rolling resistance and therefore may require more power but, from a safety point of view, ballast is beneficial.
- Extra ballast can be added inexpensively and more conveniently by filling the tyres 75% full with water.
- If you pull a load from the rear of a tractor, the weight will be transferred from the front of the tractor to the rear wheels. This will occur even if the pull chain is attached to the front axle.
- When going downhill with a bare tractor (no implement attached), reversing will provide better traction than going forward. However, this can be ineffective if tyre treads fill with soil and do not clear. This applies particularly to 2WD tractors.

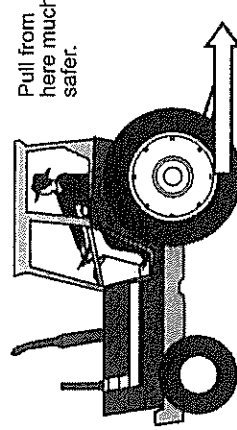
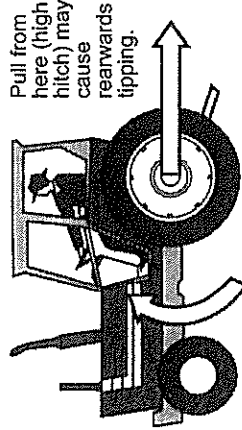
Note: Applying the brakes suddenly in such a situation can cause the tractor to flip over backwards.

19. Longitudinal Stability

Longitudinal stability relates to the tendency for a tractor to roll over forwards or backwards.

Rearing Up

- It can take less than half a second for the front of a tractor to rear up to a vertical position.
- On some surfaces (e.g. rolling silage stacks), the rolling resistance may be so great that a tractor will flip over backwards going up what would otherwise be considered a very mild slope. **Always add front ballast to tractors when rolling silage stacks or, alternatively, reverse up the slopes.**
- Operators need to be aware that if a tractor has sufficient traction at the rear wheels, it can rear up even if the hitch is only 1cm off the ground. Steel wheels will provide such traction; rubber tyres seldom will.
- Never tie a post or log across the front of the rear wheels to aid recovery of a bogged tractor as this is likely to cause the tractor to tip over backwards rather than help it climb out of the bog.
- When reversing downhill quickly (even without the engine running), sudden braking may cause a rearward flip-over. This is due to reaction torque within the brakes in exactly the same way as reaction torque is caused in the final drive when a tractor is driven forwards uphill.



When pulling a load, hitch only to the drawbar.

- Sudden acceleration greatly increases torque and will, therefore, transfer weight to the rear of a vehicle. (Motorcyclists who "pull wheelies" do so by accelerating sufficiently to lift the front wheel off the ground.) Use gentle, even clutch release to reduce the risk of the tractor rearing.
 - A downward, angled pull on the drawbar will produce more weight transfer (from the front of the tractor onto the rear wheels) than a horizontal pull at the same height.
 - Claims that partially applying the brakes will reduce the likelihood of tractor rearing when travelling uphill are false. Braking in this situation will only result in a lot of internal stress in the transmission and will wear out the brakes. However, where a differential lock is absent, braking may help to even out the traction for both wheels.
 - An implement carried on the three-point linkage will not prevent a wheel tractor from rearing up. Unlike the blade on the front of a crawler tractor, there is no restriction to upward movement of the three-point linkage (and, therefore, the implement) until it reaches the top of its travel. Even in the fully up position, the angle on the linkages (particularly the top link) is so extreme that they may fail when the tractor rears up. There is an even greater risk when a chain is used as the top link.
 - Tractors that have a step-down gearing in the final drive to the rear axle will rear up when pulling a load as easily as a tractor with a straight-through rear axle drive.
 - When a tractor rears up as a result of pulling a load (e.g. from too high a hitch), it pivots about the point of contact between the rear wheels and the ground (not the rear axle). When a tractor rears under these circumstances, the rear wheels may actually roll backwards slightly. In other circumstances, the rear wheels may roll forward slightly, or forward first then backwards.
 - When a tractor rears up due to a heavy load on the 3-point linkage, ascending a very steep hill or the rear wheels becoming wedged in a drain, it pivots about the rear axle. The rear wheels do not roll backwards.
- The Effects of Ballast (extra weight) on Longitudinal Stability**
- **Adding wheel-weights to a tractor is one of the safest ways of adding ballast.** This is because the centre of gravity of a tractor is usually higher than the rear axle (as well as the front axle). Wheel weights place more weight below the centre of gravity than above it, thereby increasing longitudinal stability.
 - **Adding water to the tyres as ballast is safe for the same reasons described above.** If the tyres are filled only to valve-level (i.e. not 100% full), the distribution of weight below the centre of gravity is even greater (and is, therefore, safer) than when cast iron wheel weights are used.
 - If you wish to ascend a hill with a two-wheel-drive tractor, two options are available. Driving up forwards will gain best traction but risks the tractor rearing backwards. Driving up backwards avoids the risk of a rearward flip but sacrifices maximum traction. The safe course is to add sufficient ballast to the front of the tractor to allow you to drive up forwards without flipping over.
 - The biggest safety feature of four-wheel-drive on a tractor is that it adds weight to the front of the tractor, which reduces the chance of rearing upwards, gives better braking (traction) and sometimes better steering on hills.

20. Lateral Stability

Lateral stability relates to the tendency for a tractor to roll over sideways.

Terrain and Roll-overs

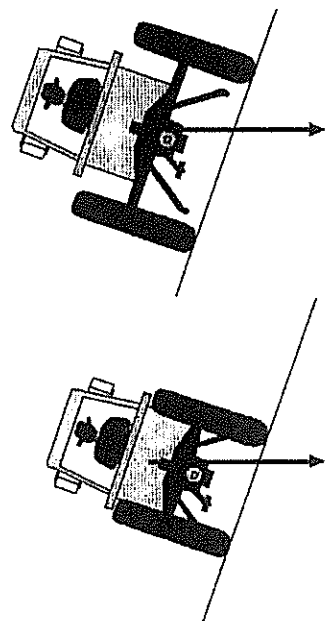
- Most tractor accidents occur on relatively flat ground (less than 9° slope).
- There are twice as many roll-over (sideways) tractor accidents as there are rearing-over-backwards accidents.
- If the rear wheel hits a bump or drops into a hole while the tractor is travelling at speed (even on flat terrain), the tractor's momentum can be sufficient to cause a sideways roll-over.
- Light rain or heavy dew can make a normally safe slope dangerous to drive upon. Drivers must remain alert and learn from a range of driving experiences.

The Effects of Ballast (extra weight) on Lateral Stability

- Adding ballast in the form of wheel weights or water in the tyres improves lateral stability by lowering the centre of gravity.
- Lifting a heavy weight on a front-end loader is particularly dangerous. This may cause the rear wheels of the tractor to lift off the ground, allowing the whole tractor to pivot on the centre of the front axle and resulting in the tractor falling over sideways. Use a heavy rear-end weight when using front-end loaders, even if you think the traction will be adequate.
- A tractor with a lower centre of gravity is less likely to roll over sideways.
- When a tractor is on a slope that changes the vertical line of action of the centre of gravity so it is directly above the tipping axis, the tractor is in danger of tipping over. Anything that lowers the centre of gravity or widens the tipping axis will increase stability bringing the vertical line of action of the centre of gravity back to the uphill side of the tipping axis.
- A tractor's centre of gravity can be affected by adding ballast and attaching implements. For example, carrying a front-end-loader bucket in the raised position (especially when full) will raise the centre of gravity of the tractor, possibly to a dangerous level, thereby making the tractor unstable even on mild slopes.

Tipping Axis of a Tractor

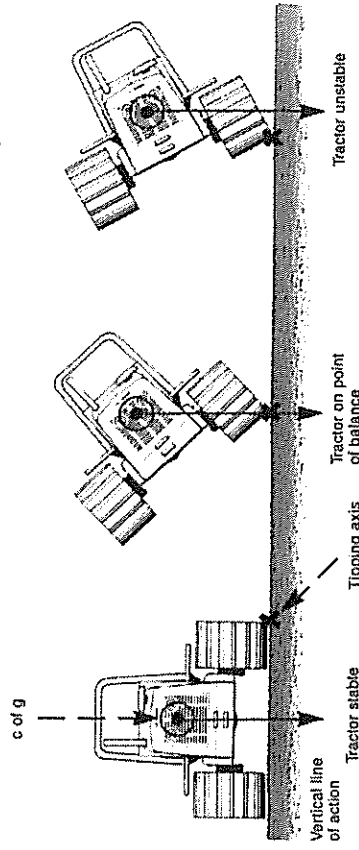
- Widening the rear wheel track of a tractor greatly improves its lateral stability as it effectively moves the tipping axis outwards.
- Dual wheels increase lateral stability by widening the tipping axis of the tractor.



- Widening the front wheel track of a tractor has little effect on lateral stability since, when a tractor starts to roll over the rear end rolls first while the front wheels remain on the ground for a limited time. Widening the front wheel track may, in some cases, help steering through.
- When travelling directly across a slope, the tipping axis (i.e. the line between the two pivot points) of a conventional tractor does not lie parallel to the slope. The front end is higher up the slope than the rear end because it passes through the centre of the front axle trunion. This is a positive situation because a tractor tips most easily when the tipping axis lies parallel to the slope.
- When travelling slowly across a steep slope you should always turn uphill rather than downhill.

21. Centre of Gravity

- If a tractor was suspended from its centre of gravity, it could tilt in any direction. The gravitational pull on a tractor also acts through this pull and it always pulls directly (vertically) downwards. If you draw a line (or hang a plumb-bob) from the centre of gravity it will always point directly downwards. This is called the vertical line of action. Provided the vertical line of action is uphill of the tipping axis, the tractor is stable. Should it pass exactly through the tipping axis, the tractor will be on the point of balance; if it is downhill of the axis, the tractor is about to or is already rolling over.



- The object of keeping any tractor stable is to prevent the vertical line of action from approaching the tipping axis. Putting a tractor in a position where the vertical line of action and the tipping axis are close together places it at risk of tipping. If the uphill track or rear wheel passes over a small bump (or, conversely, the downhill track or rear wheel drops into a hollow), the tractor is placed momentarily beyond the safety limit and in danger of tipping.
- Both the centre of gravity and tipping axis are adjustable within limits. A weight added to the tractor below the centre of gravity (lowering the blade on a crawler tractor or adding wheel weights to a wheel tractor are good examples) effectively lowers the centre of gravity, which is desirable. Conversely, the centre of gravity can be raised unintentionally, for example, by raising a bucket full of soil high on the front-end-loader on a wheel tractor or lifting the blade high on a crawler tractor. This is especially dangerous on slopes.

A wheel tractor differs from a crawler tractor in that the tipping axis runs diagonally across the tractor and is elevated off the ground at the front. Therefore, the intersection between the vertical line of action from the centre of gravity and the tipping axis occurs above the ground and is further in from the outer edge of the downhill wheel than on a crawler tractor. It also means that the tipping axis cannot be widened at the front, since it passes through the centre of the tractor. As a result, the track width of the front wheels (i.e. the distance between them) has no influence on lateral stability. The track width of the rear wheels, however, is still very important. The wider apart they are, the more tolerance there will be before the vertical line of action of the centre of gravity approaches the tipping axis.

Remember: Most tractor fatalities occur on relatively flat ground.

22. Wheel Slippage

- When using implements on your tractor, some wheel-slip is needed to generate pull. The amount of pull needed by an implement is known as its draught load.
- Wheel-slip must be close to the optimum to keep the tractor working at or near top efficiency. Table 1 shows what you should aim for, depending on soil condition and tractor type.

Table 1 – Optimum Wheel-slip for Various Tractors and Soil Conditions

Tractor Type	Uncultivated Soils	Cultivated Soils
2WD	7 – 11%	10 – 15%
4WD	6 – 10%	8 – 12%

- Too high a wheel-slip will lead to a loss of power through a reduction in ground speed and unnecessary tyre wear. Low wheel-slip levels indicate that the tractor is too heavy for the load it is pulling, rolling resistance will be excessive and the soil properties are not being fully utilised. If the measured wheel-slip is not close to those given in Table 1, corrective action must be taken.

Wheel-slip too low:

- Reduce tractor weight by removing cast ballast weights.
- Increase the drawbar pull on the tractor by pulling a larger implement or multi-couple implements.

Wheel-slip too high:

- Add ballast to the tractor or transfer weight from the implement onto the tractor either with draught or pressure control. This should be done without exceeding tractor or tyre weight limits.
 - Reduce the draught load on the tractor. Reduce the pull required (e.g. cultivate at less depth).
- One important point to remember is that, with most implements, changing forward speed will not significantly alter wheel-slip. Wheel-slip is determined by the drawbar pull required – the higher the drawbar pull, the higher the wheel-slip.

Measuring Wheel-slip

- Wheel-slip must be measured as it is not possible to visually estimate the levels shown in Table 1. If you can see the driving wheels slipping, wheel-slip is in excess of 25%. When working a tractor at the same job for long periods, a little effort spent measuring wheel-slip will save time and measure fuel and reduce tyre wear.
- To calculate slip, first mark and measure the distance travelled for 10 revolutions of the driving wheels with the implement in work (the loaded distance) and repeat this with the implement either out of work or disconnected (the unloaded distance). Subtract the loaded distance from the unloaded distance, divide the result by the unloaded distance and then multiply this by 100. This is the percentage slip, or
- To calculate the percentage of wheel slip use the following formula:

$$\text{Wheelslip \%} = \frac{\text{Unloaded distance} - \text{loaded distance}}{\text{Unloaded distance}} \times \frac{100}{1}$$

Rolling Resistance

- The rolling resistance of a wheel is equivalent to the force required to move the wheel forward over a given surface. Obviously this is much less on a hard surface than on a soft one – the reason being that on a soft soil surface the wheel sinks in then has to roll against an 'uphill' wedge of soil. It does not actually climb this wedge but compresses the soil and, in doing so, engine power is absorbed. This loss of power reduces the draw bar pull that the tractor can generate. Keep rolling resistance to a minimum.
- Two alternatives are available to decrease rolling resistance:
 - Increase the contact area between the tyre and the soil. This can be achieved with wider tyres, larger diameter tyres and/or lower tyre pressures.
 - Decrease the weight of the tractor, (remove cast ballast weights).
- Soil compaction is closely related to rolling resistance so any reduction in rolling resistance should also reduce soil compaction.

23. Hydraulic Depth and Draught Controls

- Tractor hydraulic systems vary so consult your operator's manual for the details needed to operate the hydraulics on the tractor you drive.

Depth Control (position control)

- This control setting holds an implement at a constant position relative to the tractor. It attempts to maintain an even working depth at all times.

Load or Draught Control

- This control changes the depth of the implement as the force on the draught load-sensitive top link (of the 3-point linkage) changes. Therefore it will lift a plough out a little in heavier soil and allow it to drop back in on lighter soil.
- Draught/load control for hydraulic mounted implements or pressure control where available for trailing implements will result in an increase in work output and reduced fuel consumption when used as outlined in the operator's manual.
- Draught/load control is a system that automatically maintains the implement at a set load. As the soil resistance increases or decreases, the hydraulic valve adjusts automatically.

Mixed Control

- Some modern tractors allow us to mix the control between depth and load. This fine tuning of the systems can be very helpful, allowing some change of depth (i.e. allowing the load to change also).

Float

- This is where the arms are allowed to float up and down, adjusting to and follow the contours of undulating terrain. Implements need to have their own depth-controlling wheel for this to be successful.

24. Engine Efficiency

- Different makes of diesel engine vary in efficiency. There is also a wide variation in the efficiency of any particular engine across its speed and load range. Best efficiency is gained when the engine is under constant high load, particularly in the mid-speed range.
- The engine sound will tell you how much load is on the engine. Under most conditions, if the engine note sounds fairly constant, it is operating under governor control (i.e. at part load). If the sound varies in pitch with variations of ground conditions or if closing the throttle slightly makes no difference to engine speed, the engine is operating on full load. Try to set the throttle just below the point at which it affects the engine speed. This will ensure that the engine is working at high load but is still controlled by the governor. During heavy operations match implement size to the tractor (multiple coupling of implements can help here) to keep the engine working at or just below its rated speed.
- At slow forward speeds, the tractor requires wider implements to fully utilise its power. However, if the implements are too large they will cause too much wheel-slip. If you are forced to use light implements with a tractor that is too powerful (i.e. a mismatch), select the highest gear you can use comfortably and safely, with the engine running at about 60% rated speed.
- The New Zealand Agricultural Engineering Institute found that a tractor used 15% less fuel at lower speeds than when it was operated at maximum engine speed. The saving was achieved simply by running at a lower engine speed in the same gear and consequently, work rate (hectares per hour) fell by 25%. By changing up one gear, fuel consumption remained low but work rate increased by 10% over the maximum achieved in the lower gear. Optimum setting was 1600 rpm. Your tractor may vary from this so try setting it 200 rpm each way.