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Compact Tractors in Forestry

INTRODUCTION

Small-scale compact tractors are commonly used in the UK for horticulture and grounds maintenance. There is a growing interest in their use for forestry applications.

Compact tractors are defined by their compact dimensions, and are commonly below 50HP, although more powerful models are available. With a large range of attachments, compact tractors can be used for timber processing, extraction, ground preparation, mowing for amenity and conservation, transport of equipment and materials and ongoing management tasks.



Figure 1 Small-scale alpine tractor and purpose-built forwarding trailer

BACKGROUND

Small-scale tractors have been used in forestry for many years and companies such as Holder and Kubota are well established manufacturers. There is growing interest in small-scale equipment for forestry management and many new models are entering the UK that show a potential for a wide range of forestry applications, especially ‘alpine’ tractors that have been developed to operate on steep terrain and in confined conditions in vineyards (Figure 1).

ADVANTAGES OF COMPACT TRACTORS IN UK FORESTRY

The small size of compact tractors enables excellent manoeuvrability for forest operations such as timber extraction (Figure 2). Despite their small size, the power to weight ratio of compact tractors is comparable to that of larger machines. Smaller does not necessarily mean that compromises in structural strength have to be made. Many alpine tractor axles for example have the same cross-section dimensions as larger machines; and are made shorter rather than scaling down the axle in proportion to the overall size which would compromise durability.

Narrow width dimensions allow compact tractors passage where machine access is restricted such as nursery plantations or tightly spaced stands. Many models offer frame steering allowing for tighter turning circles, well suited for gaining access between standing trees.

Compact tractors can cause less ground compaction compared to similar larger scale machines due to their proportionately lower weight and large footprint area (the area in contact with the ground).

Reduced site impact and narrower dimensions means that lower specification access tracks are required when compared to those needed for larger machines, reducing track construction costs. Most compact tractors are available with 4-wheel drive and articulating axles, providing traction, slope and terrain capabilities suited to forestry conditions. Ground clearance could be a limiting constraint for their use in forestry where terrain is rough due to ground preparation or rutting from previous extraction equipment.



Figure 2 Narrow dimensions allow access on narrow tracks with minimal disturbance to trackside vegetation

For many small woodlands the scale of operations such as establishment, maintenance and timber extraction would make bringing in larger machines uneconomic. Compact tractors can provide a means of managing small woodlands more economically by appropriately tailoring the scale of the machine to the operation.

Many compact tractors have power assisted steering which aids operator ergonomics. They have larger and more comfortable operator platforms than many other small-scale machines. The flat deck operator platform is free from obstructions that may hinder the movement of the operator, and therefore enables the operator to easily get on and off the machine during work, as is common with many forestry work activities.

A standard agricultural three-point linkage is common; most compact tractor linkages are category 1. A PTO shaft is also standard, ruling out the need for attachments to be self-powered, so reducing their weight and cost. The inclusion of a standardised three-point-linkage and PTO drive means that compact tractors are a very versatile machine option, capable of coupling to a wide range of forestry and farming equipment including forwarding trailer, skidding winches, flails and mowers.

Most compact tractors are fitted with a standard 540 or 1000 rpm six-spline PTO shaft, should non-standard equipment need to be used then it should be checked that suitable adapters are available. Note: It is a legal requirement that the PTO shaft be fitted with a guard which should always be in place to protect the operator from danger when the PTO is in use. Many models feature ground speed PTO to drive attachments at the same rate/speed as the tractor in motion. A ground speed PTO suits tasks such as fertiliser application where the rate of application reduces if the speed of the tractor slows.

Compact size allows transportation to site on a small trailer (Figure 3), reducing the initial machine placement cost on site rather than incurring the cost of transportation e.g. by low loader, which can be necessary with larger machines. Due to the wide range of attachments, compact tractors are not restricted to a limited number of specialist tasks as is the case with specialist forest machinery such as mini-forwarders.



Figure 3 Transport to the forest worksite on a dual purpose trailer that can be converted into a forwarding trailer for use in the forest

Small-scale machinery is most economically operated in small-scale forest operations. As the area to be worked and travel distances increase the use of compact tractors becomes inefficient. The scale of the machinery should always be appropriate for the task. As long as the size of the machine matches the scale of the operation the advantages offered by compact tractors make them ideally suited to a wide range of forest applications.

The cost of some units may be prohibitively expensive for forestry use where margins are slim, especially when compared with the cost of readily available second hand large-scale machinery.

Compact tractors developed for agricultural use may not be sufficiently robust to operate in a forest environment, however additional guarding may improve tractor durability for forest use.

The effect on stability and centre of gravity must be considered when selecting any ancillary equipment for compact tractors. Where tractors are to be operated over environmentally sensitive sites the use of bio-oils may be considered.

The lighting on the tractor will determine the level of visibility afforded to the operator during use in dark or shaded under-canopy conditions. Additional lights may be required if operating in poor light conditions.

If access in the forest is confined, a tractor with high mobility may be a preferred option. A frame-steered tractor (where steering is through a pivot and hydraulic rams in the middle of the tractor has a high degree of manoeuvrability. Units with frame steering may sacrifice a degree of structural integrity compared to equivalent wheel-steered tractors, as a great deal of force is exerted through the point of articulation.

The small size of compact tractors reduces the available space for stowage of equipment; ideally the tractor should allow storage of tools, first aid kit and chemical spillage kit and fire extinguisher. However these could be carried on accompanying vehicles.

SAFETY CONSIDERATIONS

All compact tractors and ancillary equipment should be CE marked and comply with the Supply of Machinery Regulations, as well as adhering to the requirements of the Provision and Use of Work Equipment Regulations 1998 (PUWER) and where applicable the Lifting Operations and Lifting Equipment Regulations 1998 (LOLER). Under PUWER 98 machinery should only be used for operations for which it is designed. If in any doubt, users should confirm with the manufacturer that any particular machine is suitable for the operation and site conditions.

Roll Over and Falling Object Protection

Compact tractors can offer superior operator protection compared to many alternative small-scale machines in terms of Roll Over Protection System (ROPS) and Falling Object Protection System (FOPS). The risk assessment process should ensure the machine meets appropriate protection requirements for a defined task. The ROPS (Figure 4) acts to protect the operator by preventing crushing in the event of the machine rolling over. ROPS consists of a bar or frame (this can also be built into a cab) that encloses the operator in a zone of safety if the machine rolls over.

Fitting of a ROPS is considered a sensible and achievable measure to tackle the risk of operator injury, and this is stated within PUWER. Consequently ROPS should be fitted if there is a possibility of mobile equipment rolling over during use (Note: some exceptions to this requirement are allowed by the Health and Safety Executive).

The operator is enclosed in the zone of safety formed by the ROPS therefore it is essential that any compact tractor fitted with ROPS is also fitted with a seat belt and that this is worn by the operator to hold them securely in the machine in the event of the tractor turning over.



Figure 4 ROPS frame showing metal the plate stating the protection standard conformance. The lap restraint is also visible.

Some models offer a cab option and this can improve the comfort of the operator and improve safety for operations such as flailing and timber loading/extraction. The disadvantages of fitting a cab can include; increased weight, higher centre of gravity, increased dimensions for storage and transport, the negative ergonomic effect of restricting the operator's working environment and increased cost when compared to a rollbar. Additionally some tractors such as those with articulated steering may prove difficult or impossible to fit a cab to.

Some ROPS frames fitted to compact tractors are designed to fold down to aid transport and storage. Folding ROPS should however, never be used folded down during use in forest operations where there is a risk of the machine overturning. Note that where modifications have been made to the base machine, that will increase the overall weight of the machine and the ROPS provision may be rendered insufficient and require upgrading.

The lower weight of compact tractors compared with larger scale machinery could potentially have an effect on their stability when forwarding, transporting or spraying. The weight of logs in the loader will have a greater effect on stability compared to larger units lifting the same load. There is also the potential for load movement to have a greater effect on stability when extracting or carrying other loads on a trailer. When spraying, the pesticide in the tanks can swirl/move considerably if the tank does not have internal buffers. Such movement causes significant change to the centre of gravity of the trailed or mounted equipment; the momentum of the moving liquid increases the risk.

Where compact tractors are operated in the forest there is the potential for the operator to be subject to falling objects from above e.g. dead branches and debris dislodged during harvesting. If there is a likely risk to the operator from falling objects (more likely and potentially more severe in mature crops) then a FOPS should be provided for the operator.

Ergonomics, Noise and Vibration

Safeguarding the health of the operator by ensuring good machine ergonomics is of paramount importance when considering a compact tractor specification.

The Physical Agents Directive came into force in February 2006, bringing new controls into effect to limit personal exposure to noise and vibration and physical agents.

A noise assessment should be made of each machine or information obtained from the manufacturer with regard to noise levels, and the appropriate protection should be supplied and worn as part of the risk assessment process.



Figure 5 A simple, well-labelled control layout greatly aids ergonomics and efficient operation.

Consideration should be given to whether there is a requirement for maintaining awareness of ambient noise for safety reasons e.g. movements in crops warning of danger. This could affect the type or specification of noise protection selected. The noise level of any ancillary equipment must also be assessed. As for all forestry work activities it is important to assess levels of risk to operators using a machine through a formal risk assessment process.

Engineering Controls for Compact Tractor Safety

The following section covers the engineering controls that should be in place to ensure the safe use of a compact tractor, Figures 6, 7 and 8 list safety features and standards to be met. Some requirements are specified by law and in this context are grouped as 'must have' in Figure 6. Additional recommendations are also included in Figures 7 and 8, showing suggested inclusions in tractor specification in the interests of best practice and are classified as *should have* and *industry best practice*.

Figure 6 Features that a compact tractor *must* have

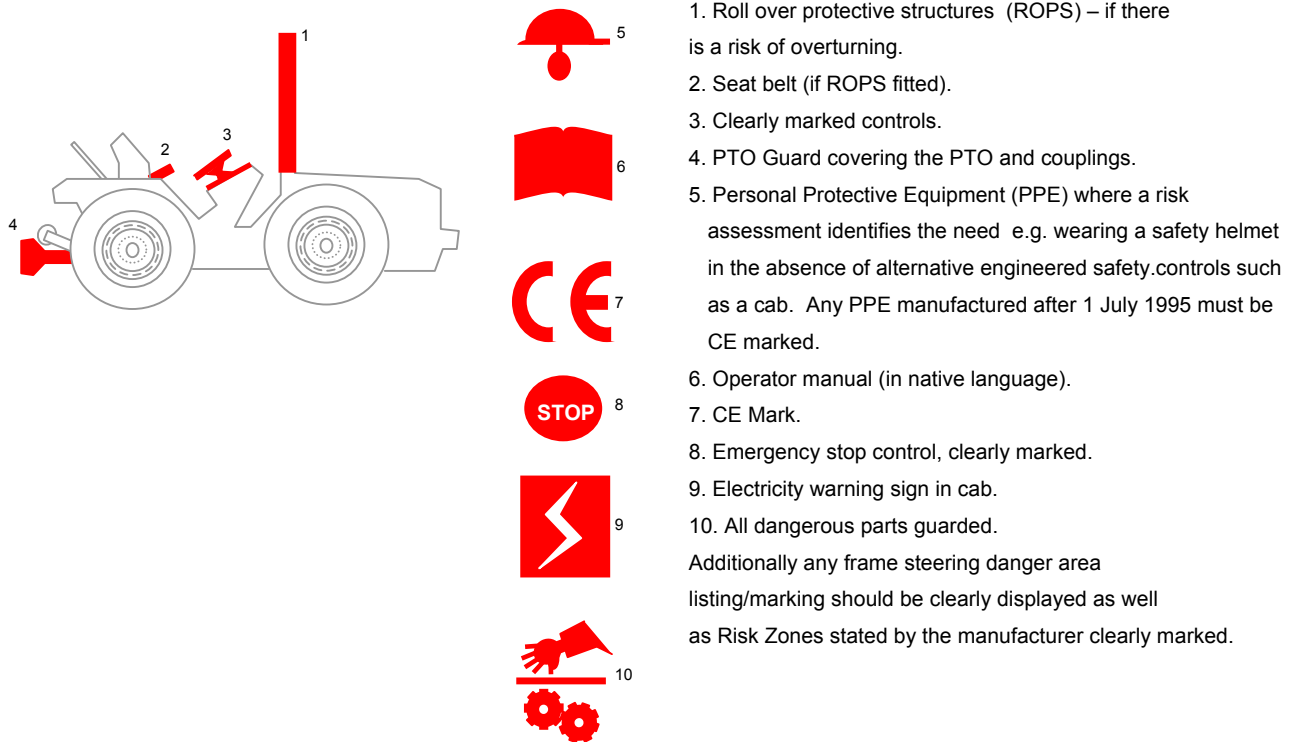


Figure 7 Features that a compact tractor *should* have

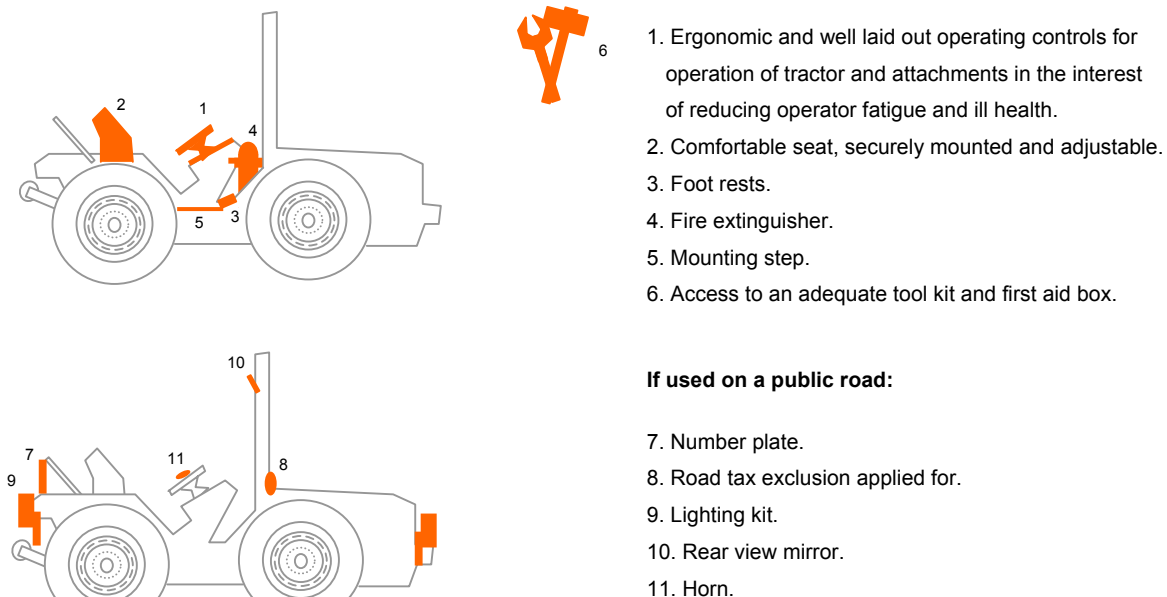
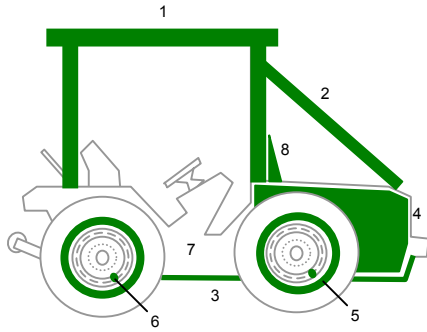


Figure 8 Tractor guarding and safety features for *industry best practice*



1. Operator cab.
2. Branch defectors.
3. Belly guarding.
4. Engine box guarding.
5. Wheel rim guarding.
6. Tyre valve guarding.
7. Clear operator platform to aid operator access on and off the unit.
8. Windscreen wipers and washers if a windscreen is fitted.

Specific ancillary attachments for use with compact tractors will often require additional safety standards to be observed including specific risk zones, additional personal protective equipment (PPE) and appropriate manual handling techniques.

The Arboriculture and Forestry Advisory Group (AFAG) is responsible for producing best practice guidance for operators and managers in the forestry industry. The AFAG series of guides have no formal legal standing, but are recognised as containing current best practice and can be used as a reference for best practice in a court of law. AFAG guides are, unlike the majority of other guidance published in the UK, specific to tractors used in forestry rather than general agricultural and land management.

AFAG guide 501 *Tractor units in tree work* should be consulted, and the advice followed by anyone using compact tractors in forestry management. AFAG requirements state that a tractor used in tree work must also incorporate a FOPS unless protection is already incorporated in the design of the ROPS, if the machine is used in circumstances where trees, cut timber or other objects can fall onto the operating position.

Personal Protective Equipment

The risk assessment should specifically identify any PPE requirements necessary due to the absence of engineering controls ensuring operator safety. Wherever possible engineering controls should be favoured over the use of PPE to safeguard the operator.

MODIFICATIONS FOR FOREST USE

Compact tractors designed principally for agricultural use may require additional guarding to protect them from damage in the forest environment (Figure 9). Such guarding usually takes the form of reinforcing around the engine housing and guarding along the underside of the tractor, protecting it from impact with ground debris including rocks and stumps.

Guarding around the wheel rims may be deemed necessary where there is a likelihood of the tractor operating over dense brash which can puncture between the tyre and the wheel rim. Similarly the vulnerable tyre valves should be guarded due to their exposed position. Any structural modifications to the machine should only be carried out with the manufacturer's approval. Where replacement components are fitted to a tractor, such as replacement bolts during general maintenance, these must be replaced by the same grade and type of component.



Figure 9 Guarding around the engine box and underbelly of a tractor attached to a mechanised flail

In order to protect the operator from protruding objects such as branches, cab windows may be guarded with heavy-duty wire mesh. Fitting wire mesh or polycarbonate affords a reasonable level of protection from penetrating objects, while not compromising all round visibility. In the absence of a cab, branch deflectors can be fitted over the front engine compartment to provide protection during manoeuvring in dense stands.

Often the positioning of the tractor exhaust will be alongside the engine compartment (Figure 10). This is a *potentially* vulnerable position. Following consultation with the supplier/manufacturer it may be necessary to guard the exhaust to reduce damage.



Figure 10 Tractor exhaust mounted in a position vulnerable to damage, next to the engine compartment

If the compact tractor is to be driven on the road then it will require an exterior view offside mirror, and if used at speeds in excess of 20 mph a speedometer and horn. Wipers should be fitted where the driver cannot obtain an adequate view of the front of the vehicle without looking through the windscreen. Two red lamps to the rear and two white lamps to the front of the tractor should be fitted as well as brake lights and indicators. Travel on roads should be covered under the risk assessment for each particular forest operation.

SELECTING A COMPACT TRACTOR FOR FORESTRY WORK

Only the end user can ultimately decide which compact tractor is the best option for them, owing to variable site conditions and the range of uses to which the tractor will be put. The following guidance aims to equip potential users with the issues to consider when selecting a compact tractor.

Knowledge of the performance of compact tractors in the forestry environment is considerably less than conventional tractors and purpose-built forestry machines. Potential purchasers should therefore take greater care when selecting machines for particular uses, obtaining advice from several manufacturers and taking care to match machine specification with desired end use.

Currently within the UK there is a large selection of small-scale tractors available within a broad price range. It is important that a suitably specified machine is chosen for the work it will undertake. Machine selection should not therefore be based on economics alone. An important concern when deciding which brand of tractor to select is the standard of aftercare and availability of spare parts and servicing offered. A company with a nation-wide dealer network is well placed to provide good after sale service backup. If the tractor is to be used in one locality then a local service and maintenance facility nearby is an important consideration. If the tractor is to be operated nation-wide for a specialist-contracted service, then a network of back-up support across the country is an advantage.

Many compact tractors could be considered expensive when compared to similar full size tractors, especially given the large number of full size second hand units available. A clear advantage should be identified when selecting a compact tractor over a larger scale machine where the initial outlay may be considerably more.

Compact tractors are commonly equipped with 3 or 4-cylinder diesel engines. Diesel engines offer good power output combined with long-term durability. If the machine is overpowered handling may suffer and manoeuvring the tractor precisely may become difficult, this is a common problem with All Terrain Cycles (ATCs).

Generally, the greater the horsepower the better as the tractor will be well suited to deal with a range of uses and site types. An appropriate horsepower rating should be linked to the most common task that the tractor will be used for. It has been suggested that as a rule of thumb, if the most common task is selected and the necessary horsepower requirement identified, then a suitable horsepower rating would be 25% over this requirement. For example if the tractor is to be primarily used to drive a chipper requiring a power output of 40 hp, then a sensible horsepower rating for the tractor would be 50 hp. Note: within a horsepower range different tractors can have very different power to weight ratios and dimensions which affects their handling and operational capability.

Adequate weight is needed for the tractor to make the most of its available horsepower and prevent wheel slip. Increased traction can be gained through the addition of wheel weights, tyre chains, varying tyre specifications, dual wheels or a combination of these. Any additions to tractor wheels must be carefully matched to the wheel and tyre size and approval should be sought from the manufacturer. If weight is unevenly distributed, there is potential for the torque of the rear wheels to result in aggressive raising of the front end reducing stability. Extra weight on the front end may reduce the risk of this possibility.

Tractor weight must be sufficient to get a good grip, however too much weight will cause flotation problems. Flotation will be linked to the tyre specification chosen. Weight distribution is critical to tractor stability. Weight distribution may alter when ancillary equipment is attached to the tractor. As the weight of the tractor changes with the addition and removal of equipment, the centre of gravity may also alter with implications for the stability of the tractor during use. It is always possible to increase the weight of a light tractor through additional weights i.e. in order to gain increased traction. It is far more difficult, if not impossible to reduce the weight of a heavy tractor.

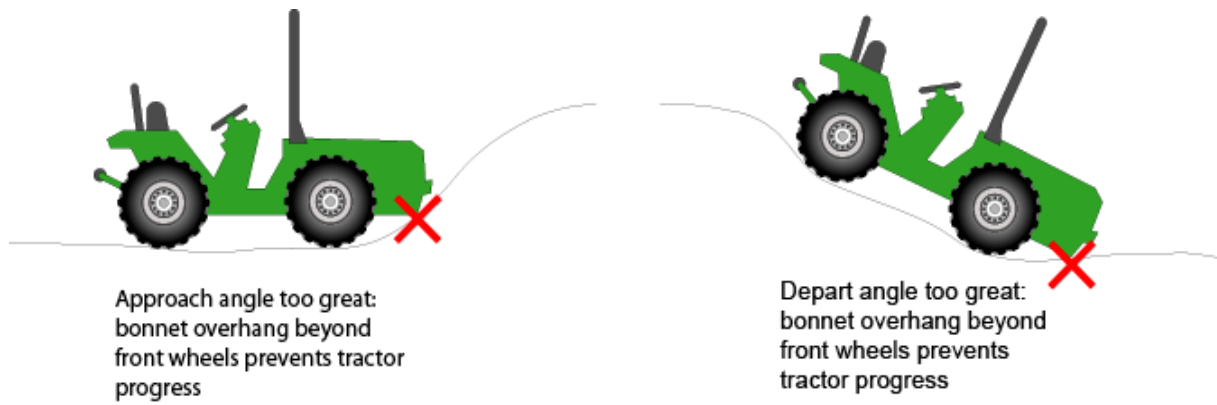
The longer the tractor wheel-base, the more stable the tractor will be although as wheel-base increases, manoeuvrability will suffer as the turning circle is increased. The larger the tractor dimensions the larger the storage space required and the wider the access-ways and tracks will need to be to accommodate the tractor. Tractor width will be influenced by tyre selection; different tyre specifications, especially high flotation tyres, will increase the overall width of the machine. Tractor width also represents a trade-off between stability and manoeuvrability. In general terms the tyres should be set as wide as possible in order to increase stability.

The length of the tractor when taken into consideration with the wheelbase will indicate the amount of overhang at the front and rear of the tractor. The amount that the engine compartment protrudes at the front of the tractor will influence the approach and depart angles (forwarding angle) that the tractor is capable of negotiating. Approach and depart angles are the degree of slope that the machine can ascend/descend before the front clearance of the bonnet impedes the tractors passage, as illustrated in Figure 11. The approach and depart angles should be carefully considered when operating on undulating, sloping terrain.

The height of the tractor will once again be influenced by the tyre selection; tractor height directly affects the centre of gravity. Fitting larger tyres to the tractor will raise the height of the machine, the ground clearance is increased but the centre of gravity is raised, reducing stability. It is desirable to have as low a centre of gravity as possible to maximise machine stability. Where the tractor will operate over very uneven terrain, a low centre of gravity becomes critical to prevent machine rollover.

Ground clearance of 30 cm is desirable as a minimum requirement, although in certain situations and locations where the tractor will be operated only on even ground, a lower ground clearance could be acceptable.

Figure 11 Limitations of approach and depart angles due to the protrusion of the tractor engine housing



ANCILLARY EQUIPMENT FOR COMPACT TRACTORS

Following the introduction of compact tractors into the UK during the early nineteen eighties implement manufacturers have produced, in scaled down form, virtually every implement and accessory that is currently available for larger tractors. The huge range of attachments available for compact tractors makes them very versatile for forestry work. Compared to other small-scale machines compact tractors often have greater towing capacities (typically over 1 tonne). This is an important consideration for example when extracting timber with a forwarding trailer where load size directly affects the economics of the operation.

Before attaching any implement, it is critical to remember that the compact tractor's small size may have been achieved partly at the expense of strength. Caution must be exercised where equipment is attached directly to the machine e.g. front-end loaders, back hoes etc. with reinforcing sub-frames being fitted as necessary. Manufacturers and suppliers should be consulted prior to use. Any machine failure as a result of fitting inappropriate equipment may devalue the tractor manufacturer's warranty and compromise safety.

The relatively wide axle spacing and a low centre of gravity give compact tractors excellent longitudinal stability. However, they typically have relatively narrow wheelbases. Although this improves their manoeuvrability it does adversely affect lateral stability and therefore requires appropriate driving practices and sensible loading. Check base machine and attachment compatibility with the manufacturer, both operationally and on the grounds of safety.

Any force acting upon a relatively lightweight tractor above its centre of gravity may have a disproportionate impact on stability, particularly when working on slopes. Increasing the axle width by fitting wheel spacers or twin wheels will improve the situation. This will impact not only on manoeuvrability and cost but also exacerbate bearing and transmission wear. These factors are of even greater significance when considering fitting implements to compact tractors that are frame-steered.

CONCLUSIONS

Small-scale compact tractors show excellent potential for forestry work in a variety of applications. Anecdotal evidence suggests that niche uses best suit compact tractors in forestry; these include small-scale timber extraction and management operations such as mulching and mowing where access for larger machines is restricted.

Compact tractors offer specific advantages in terms of reduced site impact and manoeuvrability compared to larger scale tractors, making them well suited to sensitive forest harvesting and management sites. Compared to other small-scale machinery options compact tractors offer considerable safety and ergonomic advantages to operators.

The versatility offered by compact tractors, due to the large range of compatible ancillary attachments, gives them an appeal over many purpose-built machines designed to carry out a restricted range of functions such as dedicated mini forwarders. The compact tractor base unit can be used to perform a wide variety of tasks, tailored to the specific needs of the user. Although compact tractors show potential to be used in a range of dedicated operations, it is their versatility and adaptability that offers the greatest benefit for those involved in forest and estate management.

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