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Tractor-Mounted Lifts

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Introduction

The average age of farmers in Virginia is steadily increasing and many of them experience age related disabilities (Mariger, et al., 2009). Many with disabilities are interested in continuing their work. Often they can do so if appropriate assistive technologies (AT) are available to carry out their responsibilities without risking secondary injuries. For example, most disabled farmers are able to work if the equipment work space can be accessed without the risk of secondary injuries. One of the ATs widely used in assisting disabled workers to access a tractor or other equipment work space is a mechanical lift. These lifts are often custom-designed and fabricated locally to keep the cost down, and to make it adaptable to different makes and models of tractors.

Virginia AgrAbility program has been engaged in the development of assistive technologies to keep farm workers productive. As part of this program, we have designed two different types of mechanical lifts – vertical and inclined. In order to introduce these designs to potential users, Virginia AgrAbility has developed the following three factsheets:

1. Tractor-mounted lifts
2. Tractor-mounted vertical lifts
3. Tractor-mounted inclined lifts

The first factsheet covers the general description of mechanical lifts including the different types that are available. In addition to safety considerations, this factsheet also discusses topics such as potential hazards during the use of mechanical lifts, design considerations, and the design criteria that are taken into consideration during the development of either vertical or inclined mechanical lifts. One may also go to (www.agrability.org) for additional information.

The remaining two factsheets cover either the vertical or inclined mechanical lift. Individuals interested in tractor lifts should first study Factsheet #1. This factsheet will help to select the appropriate type of lift. Depending on the selection, Factsheet #2 or #3 may then be reviewed for specific information on the type of selected lift.

Lift Types

Basically there are two types of mechanical lifts– vertical and inclined that can be mounted on tractors. Vertical lifts are commonly used to access farm equipment. When this type of lift is used, the worker may be either sitting on a seat or standing on a platform while he/she is lifted up vertically to the operator's platform. On larger equipment such as tractors, combines and skidders, a vertical lift equipped with a platform has the capacity to accommodate an operator on a wheelchair while being lifted on to the operator's platform (Figure 1a and c). Vertical lifts are more common on smaller equipment.

The inclined lifts (Figure 1k), on the other hand, are more common on larger or medium sized equipment. They are generally located between the front and rear tires. Inclined lifts have the potential for incorporating a number of safety features.

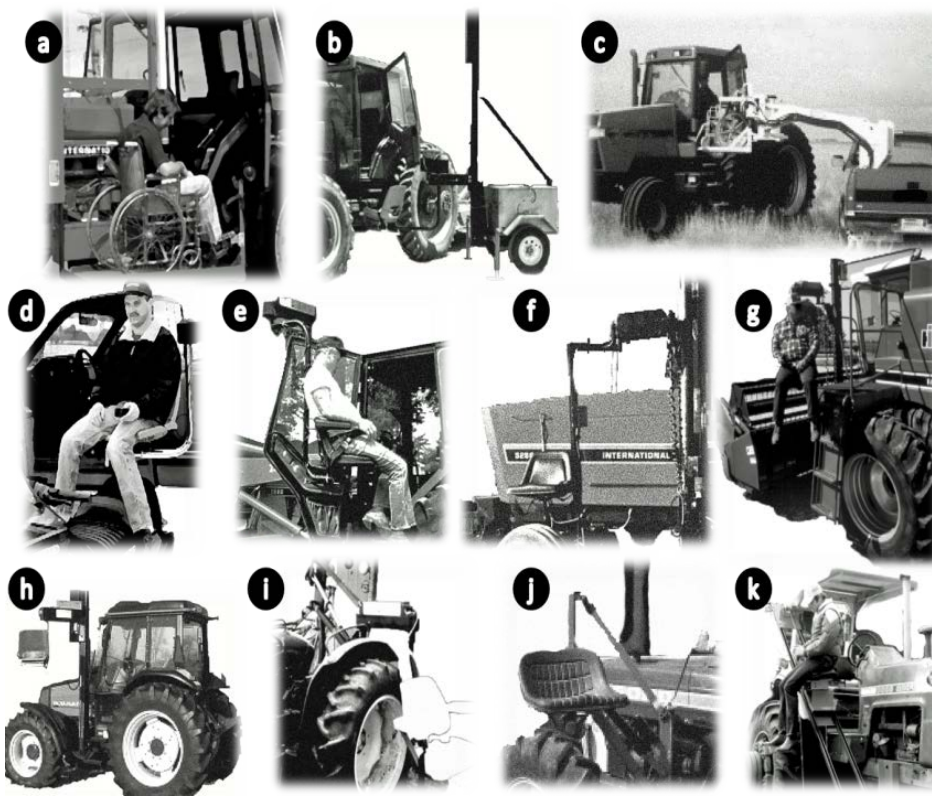

Figure 1. Various lifts for tractor access. The vertical lifts displayed above (pictures a-k) all have a seat that is different than the driver's seat. **a** For larger tractors, a full platform can be mounted onto a vertical lift that enables a wheelchair user access to the cab of the machine. **b** There are vertical lifts available that are portable, such as the trailer-mounted independent lift on a ball hitch, and that lifts the user in entering any size tractor or combine. **c** More industrial versions, like the Freedom Lift pictured here, can be used to access multiple pieces of equipment, but may require more than one operator. **d** When mounted in the rear of a truck, this lift system can be used to get in and out of the vehicle. **e** Vertical mast chair lift; mounted in front of tractor cab. **f** Vertical mast chair lift with a chair connected to a swing arm. **g** Vertical mast lift on a combine. **h** Vertical mast chair lift; employs three motors. The vertical lifts displayed here are all mounted on each vehicle and have a swinging arm that allows the operator to transfer into the tractor or combine seat. **i** The hybrid lift also acts as the seat of the tractor. **j** The parallel-linkage lift is mounted to the side of a smaller tractor and swings in to provide transfer to the driver's seat. **k** This is a winch driven cable lift that rides on inclined rails and allows the operator access to the cab of a tall tractor. While relatively easy to construct, this type of lift could pose a major safety risk if the cable or winch failed.

Other types of lifts are either truck mounted or shop mounted lifts. Truck mounted and shop mounted lifts (Figure 1c) make use of a long swiveling arm to pick up the operator and place him/her on the operator's seat. These lifts are particularly useful when the workers have to access the operator's seat on different equipment. However, the disadvantage of

these lifts is that they are not available to the operator in the field if there is an emergency. The other advantage of a shop lift is that they are protected from weather conditions. The stationary lifts can be large because they do not have to fit into a limited space. A compromise between all the three types of lifts discussed above is the lift on a trailer that can be drawn along by the side of an equipment (Figure 1b).

Figure 1 (Yoder, et al., 2000) shows different types of mechanical lifts used for accessing a tractor operator platform. Design details of these lifts are available at the National AgrAbility website (www.agrability.org/). Since tractor specifications vary when adapting an existing design, mounting location and space availability for mounting the lift must be evaluated carefully. It is also important that the user spend adequate time evaluating types and designs of lifts, taking into consideration the equipment specifications before the selection.

Purchasing a Lift

When the use of a mechanical lift is under consideration, the question often asked is whether one should purchase a commercial unit or custom design and fabricate. If a commercially produced unit (Figure 1) that meets the specific needs of the user is available at an affordable cost, it may be the best choice. In addition to saving valuable time, commercial units are generally safer because they undergo considerable testing before they are marketed.

Another option is to consider retrofitting used lifts. When a pre-owned lift, meeting the specifications, is located, it should be evaluated to make sure that it meets the established safety standards and it operates properly. The following websites are helpful in locating pre-owned lifts:

- FREE (Foundation for Rehabilitation Equipment & Endowment): http://www.free-foundation.org/
- Disabled Dealer: http://www.disableddealer.com

When a suitable commercial or pre-owned unit cannot be located, one may have to custom design and fabricate. If that is the case, this publication together with the factsheet on either the vertical lift or the inclined lift can help accomplish this goal. The custom design and fabrication may allow one to cut costs with the use of surplus or recycled material.

Regardless of the type of lift selected; evaluation, design, and assessment of specific needs of the individual must be done in consultation with specialists in the Department of Rehabilitation Services (DRS), Rehabilitation Engineers, Virginia AgrAbility Personnel and Extension Agents. These professionals are trained to evaluate individual cases and generate solutions that will meet the medical and business needs of the individual.

Design Criteria

Establishing the design criteria is the first and most important step in any design process. The design criteria for the mechanical lift should be developed taking into consideration the special needs of the operator, equipment specifications and constraints, and safety requirements. The following are selected specific items that need to be considered during the establishment of design criteria:

1. *Platform versus Seat-type Lift.* This decision may depend on the type of disability of the operator. In either case, before placing a disabled person on the operator's seat, the lift should have the capacity to lift the individual to the appropriate height (approximately nine feet). It is also important that the design should allow the transfer of the operator to occur across level surfaces.
2. *Lift Location.* The location of the lift to a large extent depends on whether the operator needs to operate different pieces of equipment or only one, and whether there is adequate space on the equipment for mounting. For example, if the person is interested in mounting only one vehicle, and if there is adequate space for locating the lift, then the appropriate action is to select either a vertical or inclined lift. On the other hand, if he/she is interested in operating several different pieces of equipment, then it is reasonable to consider either a truck mounted lift or shop mounted lift.
3. *Design for Easy Mounting and for Minimal Alterations on the Tractor*. If the lift system is designed for minimum alteration on the equipment, it will help keep total costs down. In addition to making the mounting and dismounting of the lift easier, this criterion will also help to reduce the opportunities for adversely affecting the performance of the equipment.
4. *Lift capacity.* Variables such as lift capacity, speed, and lift height have significant influence on the total cost. Any increase in any of these variables, will increase the cost of the lift. Therefore it is important that the designer come up with the ideal combination to keep the cost down. Weight and speed ranges may vary from 200 to 300 pounds and 4 to 20 feet per minute, respectively.
5. *Power Source*. Ideally the lift system should be designed to operate on the electrical system on the tractor. However, it is important that the lift is operable even when the tractor is not running.
6. *Safety Features.* Protecting the disabled operator from secondary injuries is of prime importance when designing a human lift. Safety switches, provisions to lift or lower the person in the event of power or mechanical failure must be considered and incorporated into the design.
7. *Safe Escape Routes*. A safe exit route in the event of an emergency must be identified and incorporated into the design.
8. *Operational Flexibility*. Most heavy equipment is expensive and it is not economically feasible to dedicate expensive equipment only for the use of a single operator. In other words, the lift system should be designed to accommodate other operators also.
9. *Fabricate with Available Parts*. Cost of the lift may be lowered if the design calls for parts that are locally available. While cost is an important consideration during design, one should not compromise safety for cost.
10. *Review Existing Designs*. Review of designs of existing systems will generally allow one to improve design and cut costs. Consider comparisons of lift characteristics in Table 1 (Jepsen, 2010; Cook and Hussey, 2002; NCSU, 2001) for long-term, successful application and safety.
11. *Design for Wide Range of Tractor Types and Sizes*. Whenever possible, the system should be designed to work on different equipment. This feature will allow the worker to operate different equipment.
12. *Actuating Devices.* The cost of actuating system goes up with its lift capacity and speed. Therefore it is important that actuating system is sized appropriately to keep the cost down. It is also important to select a system that is compatible with the electrical system on the equipment.

13. *Identify Lift Mounting Location on the Equipment.* Select appropriate mounting location for the lift mechanism, keeping in mind the convenience in mounting and dismounting. If a portable lift is selected, the entire assembly must fit into the available space.

Safety Considerations

When design alterations are made on equipment to provide access for a disabled operator, it is extremely important that injury potential of design changes be evaluated, giving top priority to the wellbeing of the client. Clients should also recognize that in all cases, a practical solution may not be feasible without the risk of secondary injuries. Occasionally, liability concerns may also prevent professionals from coming up with a solution. Selection of best solution or design should not be based only on the cost. Both cost and safety should be factored into the final selection. Our experience has shown that a "safe" solution may not necessarily be the most expensive solution.

Other Potential Hazards

As stated earlier, the professionals involved in developing the design criteria and the design for mechanical lifts should first consider the needs of the operator with a disability. When alterations are made on tractors, they create new opportunities for injuries and these may depend on the type of disability. For example, for clients who lack sensitivity in the extremities, special attention must be given to prevent contact with components that get hot (examples: engines, electric motors, and exhaust pipe). Also, to avoid cuts, operators should be protected from sharp edges and pinch points with guards.

Similarly when an operator with limited stability is involved, it is important that grab-bars and/or hand-holds are provided at transfer points. Also, for these individuals, seat belts on both the lift chair and operator's seat are extremely important to prevent falls. For individuals with spinal cord injuries, an extra person to assist with the transfer would be highly desirable.

Cable-winch lifts may pose special problems. The potential for injury is high if the winch or cable fails. This type of actuator should be avoided unless the hoist is specifically designed to lift people (certified human-lift) and is adequately secured, properly used, and maintained.

Consideration should also be given to emergency situation such as power failure, fire and malfunctioning of components. In such an emergency situation, contingency plans to bring the individual down safely should be developed and tested. All equipment operated by disabled operators must be equipped with either a two-way radio or cell phone and a fire extinguisher. They must be tested periodically to make sure that they are in working order.

Environmental hazards are also a major concern particularly when disabled operators are involved. Exposure to low frequency vibration, dust, noise, fumes, extreme temperatures, and excessive UV radiation all have detrimental effects on workers. For example, an individual with a spinal cord injury should be protected from low frequency vibration with proper seat suspension system. Operators may be protected from other environmental factors by having an air-conditioned cab.

Other safety precautions one can take to avoid secondary injuries may include the following:

1. Avoid operating the lift when the tractor engine is running.
2. Always wear seat belts.
3. Never mount the lift to both the cab and the tractor because the relative motion between them may damage the lift.
4. Avoid accidental triggering, do not mount the controls to the seat.
5. Avoid loose clothing to avoid hooking to machine components.

Concluding Remarks

Impact of secondary injuries on individuals and their families can be devastating because they are either more permanent or slow to recover from. To minimize the risk of secondary injuries, individuals with disabilities or injuries should avoid physically demanding agricultural activities. If and when this is not a viable option, use of proper assistive technologies to minimize the incidence of secondary injuries must be adopted.

WARNINGS AND DISCLAIMERS

Reference to commercial products in this publication is strictly for informational purposes. Virginia Cooperative Extension is neither endorsing these products mentioned nor discriminating against other suitable products. Information included in this document is from the National AgrAbility Program and other reliable sources. However, neither the AgrAbility Program nor the authors of this document guarantee the accuracy of the information included in this document.

The purpose of this publication is to transfer general information to clients interested in selecting or designing a mechanical lift for heavy equipment such as a tractor. If and when engineering or other professional assistance is needed, one may contact appropriate state agencies and/or private consultants.

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National Resources:

AgrAbility National Project. http://www.agrability.org/
CoachLift. www.coachlift.com
Disabled Dealer. http://www.disableddealer.com
Life Essentials. http://www.lifeessentialsweb.com
Foundation for Rehabilitation Equipment & Endowment (FREE). http://www.free-foundation.org
National Center for Chronic Disease (CDC) Prevention and Health Promotion. http://www.cdc.gov

Virginia Resources:

Centers for Independent Living (CIL's) http://www.brilc.org/
Virginia Department for Aging and Rehabilitative Services https://www.vadars.org/
Easter Seals North Carolina and Virginia UCP http://nc.eastersealsucp.com/
Virginia AgrAbility Project http://www.agrability.ext.vt.edu
Virginia Assistive Technology Partnership (VATS) http://www.vats.org/
Virginia Disability Service Agencies http://www.vadsa.org/
Virginia Farm Bureau Safety (FB) http://www.vafb.com/
Wilson Workforce and Rehabilitation Center (WWRC) http://www.wwrc.net/

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*Table 1. Comparisons of lift design characteristics**

Alternative	Advantages	Disadvantages
Mounting		
Individual Machine	Access to and from machine location	Access to only one machine
Independent	Access to unlimited number of machines	Machine can only be accessed from the location of the lift
Type		
Standing Platform	Least expensive option	Operator must be able to stand and move to the platform
Wheelchair Platform	Access to wheelchair at all times	Large and bulky Long transfer distances
Parallel Linkage	Simple to design and construct	Minimal reach and lifting distances
Chair Lift		
rail/slide	Inexpensive to design and construct	Relies on winch for power
swing arm	Greater reach (horizontal and vertical) Greater range of motion in all directions	Cost
Power		
Hydraulic	Escape capability More durable in harsh environments	Requires additional modifications More expensive components Requires the tractor engine to be operated
Electric		
winch	Least expensive option	Safety (See Safety section)
linear actuator	Made to order	Limited range of motion
chain	Easy to repair	Larger power requirement
screw	Generates large amount of force Prevents freewheeling or falls	Cost

*Modified from Yoder, et al., (2000). See Figure 1 for examples of these alternatives.