



Hay Making and Handling Made Easier

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Introduction

It has been over 50 years since the first successful automatic pickup, self-tying hay and straw baler¹ appeared on a farm in Pennsylvania.² This design, later built by New Holland, led to the development of the modern small square hay baler that is still popular in many parts of the country. All of the major and several of the short-line (manufacturers that only produce a limited type of farm machinery) farm equipment manufacturers still produce small square balers. As with almost all other farm/ranch operations over the past fifty years, continued modernization and increased mechanization has helped to reduce the labor (number of people) required for making hay. In the early to mid-1900s, making hay was almost a community event on the farm/ranch. The stationary balers of that time required that hay be brought to the implement. Operators manually tied the bales with twine/wire after the hay was fed through the machine. Today, tractor-pulled hay balers with self-feeding pickups, automatic knotters (devices that tie a knot in the wire or twine used to secure the baled hay), and bale throwers, which toss the finished bale into wagons, are a common sight on farms/ranches throughout the United States.

Although it was not always the case, the majority of hay made across the United States today is baled hay. An estimated 151 million tons of hay was harvested in 2002³. Forage harvested as dry hay is included in many rations fed to dairy and beef animals, horses, goats, and sheep. Dry hay is also a cash crop, rather than a feed source, for some farmers/ranchers. Harvesting and handling hay with new and/or modified farm machinery is physically easier and more accessible to people with and

without disabilities. Most of the adaptations made will be associated with the operator's position on the tractor or self-propelled machine. Also, bale-handling alternatives are available that can change the skills and strength required of the worker to complete tasks associated with hay production. For all farmers and ranchers, reducing the manual labor required to make or handle hay bales has been a welcome change.

Hay Harvesting

A wide variety of methods for harvesting and handling dry hay are available. Each method requires using specific "haying" equipment to complete the various tasks. With careful selection, however, most hay harvesting and handling tasks can be adapted to the abilities of the worker, which will allow many people with disabilities to make a productive contribution.

In most parts of the country, harvesting hay includes the use of a mower, rake, and baler. A healthy standing crop of hay (hay may consist of legumes, such as alfalfa or clover, and grasses, such as orchard or timothy) will have a water content of 80 to 90 percent. First, the mower or mower-conditioner cuts the standing crop and lays it in a windrow to allow the hay to dry in the field until it reaches safe storage water content levels. Next, a rake and/or related equipment moves the windrow to aid the drying process, creates a narrower windrow and/or brings two or more windrows together for a more efficient baling operation. After the raked hay has dried to the proper water content, the baler gathers hay from the windrow and compresses the hay into a denser package (bale) for ease of handling, storing, and feeding. In semi-humid climates, the hay should be protected from moisture due to precipitation (rain, sleet, snow, etc.) or absorption through the ground. A low-cost storage building will meet these needs. In semi-arid areas, the hay packages may be stored without any shelter.

To reduce the risk of damage due to precipitation, baling is sometimes done at water content levels above safe storage levels. In these cases a preservative, such as propionic acid ⁴, is added to the hay during the baling operation. Using this acid is considered safe but some workers may have sensitivity concerns.

Mowers

The first step in harvesting hay is mowing the standing crop and laying it in windrows. Most mowers used for hay production today have a conditioning unit that ruptures the stems with rollers or impellers for more rapid drying. With legumes, the leaves dry rapidly while the stem with its waxy surface dries more slowly. This is especially important in the semi-humid areas where the goal is to insure rapid drying and reduce the risk of losses in yield and hay quality caused by precipitation. In semi-humid areas, the hay will have to dry for three to four days for the water content to reach the 16 to 30 percent range.



The machines used for mowing are either self-propelled or pulled by a tractor. Accessibility and

other needs for operators with disabilities are met by addressing methods of entering and exiting the operator's station, operating the machine controls, and sitting comfortably in the operator's station. On pull type machines, the operator must constantly look both forward while driving through the field and rearward to observe machine performance (see picture on the left of a pull-type mower conditioner). The need for more mirrors and a swivel seat will be greater with the pull-type mower.

On the self-propelled mower, the cutting mechanism is located forward of the operator, therefore nearly all of the observations during self-propelled mower operation are completed looking forward. To increase machine capacity, farm equipment manufacturers are designing machines capable of higher forward speeds, some reportedly as high as fifteen miles per hour. Even at eight to ten miles per hour, the operator must be very skilled to ensure safe mower operation. At higher ground speeds, the vibration at the operator's position also becomes a potentially greater issue, especially if the operator has a disability such as a spinal cord or lower back injury.

Rakes

A rake is designed to move the mowed windrow across the soil surface or remaining crop stubble, creating a narrower windrow that will dry more rapidly. Raking should be completed before the crop reaches 40 percent water content. At lower moistures, the leaf loss can be excessive, especially in alfalfa. Hay rakes come in many different styles. One style of rake is towed behind the tractor while another style is mounted on the rear three-point hitch. One style of rake can even be mounted on a tractor front-hitch. Some rakes are designed for side-delivery of a single mower windrow, while others are designed to combine two or more mower windrows. Some parts of the country even further classify rakes as rotary, tedder, or wheeled. Below is a picture of a side-delivery rake on the left and a wheeled rake for comparison on the right.



Other "rake-like" machines used to move windrows are called "inverters" and "mergers." The inverter simply picks up a windrow and lays it on the ground inverted (turned over), which aids the drying process. More recently, mergers have become available that pick up one or two windrows and lay it on top of the adjacent windrow. Unlike hay that is raked only, inverters and mergers reduce the risk of rocks in the windrow.

All these machines are pull type. Accessibility and comfort issues on these machines

relate to the operator's station on the tractor. Since these machines are less complex than the mowers, less operator skill is required and mechanical problems requiring the operator to leave the operator's station are less likely to occur during operation than with the mower-conditioners. The tractor operator will periodically be required to observe the rake operation behind the tractor.

Balers

Hay balers are designed to create packages of more dense hay, which allow for more efficient transport. Hay balers are grouped by the type of dense package or "bale" produced; small square/rectangular⁵, large round, and large square/rectangular. The large round and square bales will weigh in excess of 750 pounds requiring transport equipment such as a skid-steer loader or a loader-equipped tractor. The more traditional baler is the small square baler, which produces bales sized so that a person can manually pick them up for transport and feeding.

Again, all three types of balers are pull-type and accessibility and comfort issues relate to the operator's station on the tractor. The tractor operator must constantly look both forward to stay lined up with the windrow and rearward to observe the baler operation. Most of the small square balers operate to the right side of the tractor and the wagon follows behind the baler, usually in line with the tractor. However, the large round and square balers operate directly behind the tractor, requiring the operator to turn around even further than is necessary for the operation of a small square baler to view their operation.

Extra: Specialty Balers



Farmers/ranchers are experimenting with smaller round bales which are small enough to be handled manually, similar to the old Allis Chalmers Rotobaler⁶. The specialty baler is often used for cattle on rotational grazing for winter feed and has also become popular with hobby-sized horse farms/ranches. These small round or "specialty" balers are usually manufactured in Europe or Japan (see picture to

the left). Since the small round bales are similar in weight to small square bales, they can be handled manually or with some of the techniques outlined in the small square bales section below.

Hay Handling

The level of physical effort required of the workers using the three most popular baling methods varies greatly. Equipment has been developed which reduces the physical exertion. In the following sections, we will review hay baling and handling methods in more detail.

Small Square Bales

Small square balers produce bales that by design are small and light enough for a person to pick up manually, ranging from 40 to 60 pounds (depending on the type of hay, the density/size of the bale, and water content). Small square baling should be done when the hay is below the 22% water range to minimize leaf shatter, mold, and heating and allow for safe inside storage. These requirements can vary somewhat around the country.⁷ The level of physical effort required of the workers manually handling small square bales (e.g., repetitive lifting of the bales from the ground to the wagon, lifting and carrying of the bales on the wagon behind the baler, from the wagon to a conveyor/elevator at the storage site, and in the storage facility) may be greater than other haying methods. New equipment that can greatly ease these physical demands is appearing all the time.

Below is a picture of a typical small hay baler being pulled/operated by a farm tractor.



In this picture, a flatbed wagon is being towed behind the baler and a person is manually stacking the bales as they are made and pushed safely out the bale chamber. Using a similar setup, the baler chamber might be extended even further to allow the bales to free-fall into a bale wagon/buggy, some of which are self-dumping. If a wagon is not towed behind the baler, the bales are allowed to drop one by one as they are made onto the ground for later pickup. This is perhaps the most physically demanding method of handling the bales, since workers have to come along later and lift the small square bales

from the ground to a wagon, and also stack the bales on the wagon.

A less physically demanding system to pick bales up from the ground would be to use an automatic bale wagon (see picture of a self-propelled bale wagon to the right), either pull type or self-propelled. These wagons, which may require the bales be turned on edge when dropped for ease of pickup, gather and stack the bales on the machine, transport the stack to the storage site, and unload the bales in stack form into the storage area. No manual lifting of bales is required with this system. Examples of bale wagons that are built by New Holland can be found at: <http://www.newholland.com/na/Products/BaleWag.html>. The bale wagon operator will be constantly operating controls and maneuvering the bale wagon to load or pick up bales from the field.



Another system that can greatly reduce the manual handling of small square bales is an accumulator system attached to the rear of the baler. In one type of accumulator, twelve bales are collected and placed in a single

layer in a rectangular pattern (<http://www.abcgroff.com/ag/hoel.htm>, <http://www.netherexe.com/accumulator.htm>). When the accumulator is full, the entire group of bales is laid on the ground at the same time.

Placing the entire group of bales in a neat arrangement on the ground then allows powered "grabbers" and special bale forks to pick up the entire group of bales and load them onto a wagon or semi/truck, and later off a wagon or semi/truck for stacking/storage

(<http://www.netherexe.com/grabs.htm>). (See picture at right of a special tractor-loader, equipped with a grabber, loading a group of bales on a wagon.) With a system like this, small square bales are easily handled in the field and during transport/storage without having to manually lift the bales. Accessibility issues are again focused on the operator requirements for access to and operation of the skid steer or tractor with loader.



Finally, if the small square baler is equipped with a bale thrower (sometimes called a "bale ejector"), then the bales are tossed directly into a steel- or wooden-sided wagon, essentially baling and collecting the hay with one pass through the field. This reduces hay handling labor in the field because the thrower tosses the bale directly into the trailing wagon. (See picture at left of a small square baler equipped with a bale ejector.)

To properly operate a small square baler equipped with a bale thrower, the operator must look both forward to stay on the windrow and rearward to observe the baler operation and to ensure the thrower/ejector is tossing bales into the trailing wagon. If the farm/ranch tractor driver has difficulty looking both forward and rearward, attempting to operate a small square baler with a bale thrower attached may not be a good idea.

Since the steel- or wooden-sided wagons are hitched to and unhitched from the baler frequently, some farmers/ranchers may find an automatic hitching system to be very beneficial when using this method of making hay.

(<http://www.agrabilityproject.org/assistivetech/resource/hitches.cfm>). An automatic hitching system permits a tractor operator to hitch and unhitch the wagon without leaving his/her seat.



Once at the farm/ranch, storing/stacking small square hay bales might be done in a combination of ways: manually carrying and lifting the bales, using a hay or bale elevator/conveyor when stacking at heights too high to reach manually or into a hay loft, or using a bale fork/grabber powered by a skid steer/tractor. Sometimes saving labor in the field can create more labor at the storage site. For example, when bale throwers are used,

the bales accumulate on the wagon in a random fashion and must then be manually unloaded from the wagon at the storage site and stacked in storage, which will require the worker to carry and lift the bales. This repetitive work is very strenuous, especially in the storage area where bales will be carried greater distances and possibly manually lifted overhead, if some sort of conveyor/elevator (see bale conveyor picture on the left) system is not used.

Likewise, transporting the bales to feed the livestock, depending upon an operation's needs, might be done any number of ways. The farmer/rancher may manually carry the bale, use a bale cart/cradle (<http://www.hansonsilo.com/haycradle/index.html>) or wheelbarrow, or a powered cart (such as those used to haul firewood) to haul bales. They might also use a lawn tractor with attached wagon, the farm/ranch tractor or truck with attached wagon/trailer, a skid steer or tractor with loader and bale fork/grabber, a utility vehicle (UV), or an all terrain vehicle (ATV) to haul bales. (See UV picture on the left and bale cradle picture on the right.)



Large Round Bales:

Large hay packages were introduced with large round balers during the 1970s. Large round bales with diameters of 4, 5, or 6 feet and widths of 4 or 5 feet can contain between 1000 to 2000 pounds of hay (roughly the equivalent of 20 to 45 small square bales) and are too heavy to handle manually.

Also, since the larger bale size makes it more difficult for hay in the core of the bale to perspire, it is recommended that the moisture content of the hay to be round baled be lower (e.g., 16 - 18%)⁸ than that made into small square bales.

Compared to small square bales, making large round bales reduces the number of bales the farmer/rancher needs to handle and may save in reduced handling and labor costs. However, some of the savings in labor costs may be offset with the need to purchase specialized equipment to transport, store, and feed the larger bales to livestock. All round balers are pulled by a tractor and require the operator frequently to observe the baler operation directly behind the tractor. Also, many round baler manufacturers recommend the operator drive in a weaving pattern left and right to ensure that the bale is uniform in diameter while forming.



To the left is a picture of a typical large round hay baler being pulled/operated by a farm tractor. In this picture, the rear of the baler is open and the completed bale has just been ejected. Once the bales are completed

(desired size and secured with twine or other wrap), the operator must back the baler up sl ejecting the bale on the ground in the field. The tractor operator would then drive forward a hydraulics to close the rear baler door without hitting the ejected bale, and once the rear ba closed, the tractor operator could resume operation to start forming another bale. Some of balers do not require backing up to discharge a bale.



Large round bales are lifted for transport or feeding us "spears" or "forks" (http://www.free-tractor-manuals.com/consumers/implements/lifting_devices/ <http://www.deweze.com/products/transport/blhugger/> these forks mount on the tractor loader, others on the hitch; still others attach to a skid loader or pickup truc (<http://www.deweze.com/products/flatbeds/index.html>). Machines are available that are ca and transporting large round bales (<http://www.pronovost.qc.ca/auta.html>). There are also picture on the left) that can be towed behind a tractor or truck that can load/carry one large bale wagons which carry up to a dozen or more large round bales (<http://www.vermeerag.com/equip/balemovers.html>).

At the storage site, a loader is required to unload the bales from the wagon and stack them. Round bales can be stored outside, or under cover, with varying degrees of hay loss.⁸ Feeding round bales to livestock can be done by feeding the entire bale inside a bale ring or round bale feeder, unrolling/unwinding the bale in a windrow, using a "slicer" to allow feeding the hay in a bunk feeder (see picture to the right), or grinding the entire bale for use in a mixing wagon. Some farmers even repackage the round bales into small square bales (run the round bale through a slicer, the output of which is fed back into a small square baler) for ease of feeding during the winter season.



Large Square Bales:

Large square bales (upwards of 800 pounds) have become very popular across the countr years. Again, part of the large square bale attraction is the fact that the farmer/rancher has bales (one large square bale contains 20 - 40 small square bales). Another part to the grov large square bales rather than large round bales is the ease of stacking them on semi-truck etc., for transport, especially beneficial in marketing the hay off the farm.

Large square balers produce very dense bales ranging from 3x3x6 feet to 4x4x8 feet. The the 3x3x6 foot long, which may be referred to as an intermediate bale in some publications balers that make this size bales and handling these bales is very similar to operating the ro handling the round bales . Large square balers usually have pre-compression chambers th produce the denser bales, therefore the suggested hay moisture content for hay that will be baled is 15%⁹ . Even so, large square bales can weigh up to 1800 pounds. Perhaps the o large bales at present is the high initial equipment cost.

To the right is a picture of a large square hay baler. Like large round bales, large square bales are usually too big/heavy to move by hand. Some specialized manual carts are available for handling large square bales (<http://www.balekart.com/>), but most large square bale handling is done with powered equipment. Some of the spears, forks,



and grabbers available for large square bales can be found at (<http://www.virnigmfg.com/default.aspx> or http://www.graysfetterangus.co.uk/farm_machinery/bale_handling.html) . There are also large square bale automatic stacker wagons, which can pick the bales off the ground and stack several on a wagon (<http://www.balebandit.com/ArcusinHome.htm>), and most of the feeding and storage options available for large round bales also work with large square bales.

Safety: Like Any Other Farm Task

Unfortunately, hay baling and handling equipment can and does cause many farmer/rancher injuries and some deaths each year.¹⁰ Safe work practices should always be followed. A good review of child safety during such farm tasks as making hay can be found at the North American Guidelines for Children's Agricultural Tasks: <http://www.nagcat.org/poster/hay/balinghay.htm>. Another very good general list of farm/ranch safety practices for hay baling and handling can be found at: <http://www.acc.org.nz/injury-prevention/ruralsafe/machinery/hay-baling/>. For farmers and ranchers with prosthetics, please review the "Farming with an Arm Amputation" tip sheet at:

http://www.agrabilityproject.org/assistivetech/tips/2_arm_amputation.cfm for other important safety reminders concerning the handling of hay bales.

Also, large quantities of dust are produced during hay harvesting and handling. Some workers will be sensitive to these dusts and special safety practices, such as dust masks and respirators may be required. A good source of dust masks can be found at: <http://www.gemplers.com/>.

References:

- ¹ . "Hay Baler": farm machine that packs and ties (or wraps in plastic) field-dried hay into bundles, called bales, for convenient handling, storage, and shipping. It ordinarily picks up hay that has been raked into rows and packs and ties it into round or square/rectangular bales to be picked up. Some modern balers include automatic stacking or loading devices. Very large bales are often stored in the field and moved with front-end loaders. Nearly all hay in the United States is baled. Bibliography: See C. Culpin, Farm Machinery (12th ed. 1992).
- ² . American Society of Agricultural Engineers (ASAE), ASAE Historic Agricultural Engineering Landmarks, #11, World's First Successful Automatic Pickup, Self-Tying Hay and Straw Baler, <http://www.asae.org/awards/historic2/summary.html>
- ³ . National Agricultural Statistical Reporting Service, 2003
- ⁴ . <http://www.dow.com/oism/prod/33.htm>

⁵ . Square hay bales are not really "square"; they are "rectangular", but it is more common to refer to square bales than "rectangular" bales, so for the purposes of this article we'll stick with the more common term.

⁶ . Plough Books - books with history and operating instructions for older Allis Chalmers farm tractors and equipment, if readers would like to familiarize themselves with them, they can be found at <http://www.ploughbooksales.com.au/35.htm>

⁷ . Nutritive Value of Hay is Critical - Press Release, 2002, Samuel Roberts Noble Foundation, <http://www.noble.org/>

⁸ . Minimizing Hay Losses and Waste, AS-119, March 2000, NDSU Extension Service, <http://www.ext.nodak.edu/extpubs/ansci/range/as1190w.htm>

⁹ . Maintaining Forage Quality and Dry Matter in Large Square Bales, Mike Rankin, UW Extension, <http://www.uwex.edu/ces/crops/LSBs.htm>

¹⁰ . National Agriculture Safety Database (NASD)
<http://www.cdc.gov/nasd/docs/d000201-d000300/d000211/d000211.html>

Resources:

National AgrAbility Assistive Technology Product Database (ATPD)
<http://www.agrabilityproject.org/search/index.cfm>

The Toolbox (Third Edition), Agricultural Tools, Equipment, Machinery, & Buildings for Farmers & Ranchers with Physical Disabilities (see Breaking New Ground web site)
<http://www.breakingnewground.info>