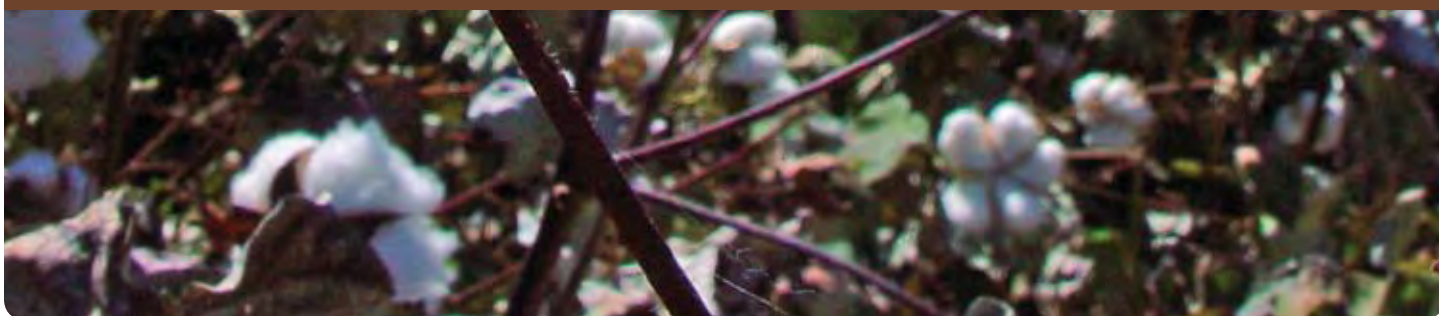




Seed Cotton Handling & Storage



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Introduction

Machines to form cotton modules at the site of harvest solved the serious problem of harvest being delayed by ginning capacity. A primary advantage of seed cotton modules has been the decoupling of the harvesting and ginning operations. By forming modules that can be stored in the field, harvest can continue when crop condition and weather allow, regardless of the ginning rate. Changes in the cotton ginning industry have resulted in modules exposed to inclement weather



for longer periods of time. The consolidation of the ginning industry has meant fewer gins with larger service areas, and thus a longer ginning season.

Protection Against Weather

If not well protected, exposing seed cotton to weather can reduce both producer and ginner profits. Rain damages cotton by increasing moisture content, reducing color grade, causing rot and heating in the module. These avoidable quality changes affect the price received by the producer, as well as increasing the cost of ginning because of increased drying energy and reduced ginning rate. Wind can blow cotton from exposed modules, resulting in less salable lint and seed.

A Brief History of Cotton Modules

For many years, trailers were the primary method of moving harvested cotton from the field to the cotton gin. Until the mid-1940s, cotton was primarily hand harvested and there was a limited effect of trailer capacity on timeliness of harvesting.

The advent of mechanical harvesting significantly increased the harvesting capacity and made trailers the limiting factor in the harvesting-ginning system. Larger and increased numbers of trailers and the gradual increase in ginning capacity could not keep up with harvesting capacity. Thus harvesters would sit idle until cotton was ginned from trailers and made available to the producer. This extended the harvest season, exposing cotton remaining in the field to undesirable weather conditions that resulted in yield and quality losses.



The Module Builder

The need for an improved storing and transporting system led to the development in the early 1970s of the module builder. This was a system in which cotton was dumped from the harvester into the module builder and the cotton compacted into a trapezoidal shape. Initially, modules were built on pallets made of either wood or metal. Further studies found that the cotton modules could be formed and stored directly on the ground without significant loss of cotton quantity or quality, so long as the ground surface was well drained.

A method of hauling the modules from the field to the gin was also developed. Initial haulers used tilting beds with rollers and a winch that pulled the pallets onto the truck. Modules built without pallets allowed the use of systems similar to those for hay bales. This included a series of parallel chains built into the tilting bed. The chains were synchronized to the ground speed of the truck when loading and unloading the module. The module truck provided a method for transporting the modules at higher speeds and longer distances.

When cotton moduling systems were initially adopted, the gins were not adequately equipped to break up the modules. The suction system used to unload trailers was slow and ineffective when feeding compressed seed cotton from modules. Early systems utilized either stationary or moving

heads that used several cylinders with lugs to remove the cotton from the compacted module, dropping the seed cotton onto belts or into pneumatic conveying systems.

Taken as a system, the module builder, transporter and feeder represented a revolutionary change in the way cotton was handled between the field and gin. The module system was adopted rapidly wherever cotton was mechanically harvested, because it provided significant operational efficiencies, both for harvesting and ginning operations.



Figure 1 A modern module builder with cab for operator comfort and hydraulic drive system. A tractor provides PTO power to drive the hydraulic pump and drawbar power to move the builder. (Photo courtesy of KBH, Inc.)

Module System Improvements

The initial module system concept evolved with many changes and improvements. The module builder used in the United States has kept the standard 7.5-foot wide by 32-foot base dimensions. Module builder height can vary from 9 feet- 6 inches to 11 feet, with the more common height being 11 feet. The choice of heights depends on other equipment used in the harvesting system. Additional improvements have been in hydraulic systems, operator controls, expanded wire sides to allow air to escape during dumping, and cabs for operators. A modern module builder is illustrated in **Figure 1**.



Figure 2 The boll buggy is used to transport harvested cotton between the harvester operating in the field and the module builder located at the edge of the field. (Photo courtesy of KBH, Inc.)

The biggest change since the early development of the module builder has been larger capacity cotton harvesters. Harvester operating width gradually increased from 2-row to 4-row and then to 6-row and 8-row. The wider multi-row units cannot dump directly into module builders because of the header width. To accommodate the wider machines and keep the expensive harvesters working, a system of using carts, known as boll buggies, was developed to transport the harvested cotton from the field to the module builders that were typically located at the edge of the field.

The boll buggy (**Figure 2**) pulled by a tractor follows the harvester through the field until the basket on the harvester is full. The boll buggy pulls along the side of the harvester, receives cotton dumped from the harvester basket, and transports the load to the module builder. This separation of the harvest and transport functions allows the more expensive harvester to spend more time

harvesting. Some harvesters and boll buggies are equipped with live chain drags on the side of the baskets so that, when tilted up for dumping, the cotton can be dumped in a more controlled manner. As more of the cotton crop was stored in modules, the need to maintain the quality of the seed cotton became apparent. Seed cotton modules are protected by placing a water-resistant cover over the top surface of the module. Early covers were made of canvas, but were gradually replaced by coated plastic materials because of lighter weight and lower cost.

Recent Developments

Engineering efforts to develop a cotton picker that would also form modules started in the late 1970s and early '80s, but it was not until 2007-09 that these systems became commercially available. Both U.S. cotton picker manufacturers sell harvesters that will compact the harvested cotton into a module. The Case IH machine makes a 16-foot-long unit (a "half module") that requires covering after unloading. The John Deere cotton picker forms seed cotton into a round module shape of about one quarter of the weight of a convention module, and surrounds that module with a plastic film that forms the cover.

These machines represent further efforts to enhance the efficiency of the cotton harvest operation. By performing both harvest and module forming operations, these machines can eliminate the need for boll buggies, module builders, tractors and labor. Accomplishing these efficiencies required compromises, however. These machines form smaller modules and have a significantly higher initial cost than conventional cotton pickers.

While these new machines produce different module shapes and sizes compared to conventional modules, the need to maintain the seed cotton quality in the package remains. **Figure 3** shows conventional modules, half modules and round modules together in a gin yard. The image was taken following a rainstorm, and water can be seen collected on the top of some modules.



Figure 3 Conventional, half-length and round modules stored in a gin yard. Photo was taken after rainfall, and some modules have water collected on the cover surface.

Module Types

With the advent of the on-board module builders on cotton pickers, growers now have an option for how to package their seed cotton for storage and transport. However, the need to protect the cotton through good practices remains the same. Some of these practices are the responsibility of the grower or his harvest crew, and some should be performed by the ginner. The following sections describe the unique factors for each module type.

Conventional Modules

The conventional practice in the U.S. is to form modules at the edge of the field using a module builder that creates 32-foot-long modules with a trapezoidal cross-section. Similar builders are used internationally where cotton is mechanically harvested, but the dimensions of the forming chamber may vary by country. After forming, the modules must be protected from the weather. Protective covers for the conventional module are available in a range of styles, materials and prices. Design differences include the material used in the top surface, skirt design (shape, depth and material), the presence of tie-down loops on the side skirts, and type of closure (rope, belt, etc.).

Case IH Half-Length Modules

The modules formed by the Case IH Module Express cotton picker are 16 feet long, rectangular and trapezoidal in cross-section. Those modules are protected with a cover similar to conventional modules but shorter in length. The number of manufacturers selling covers designed for these half-length modules initially has been limited; but with an increase in the number of Module Express cotton pickers used, the options of manufacturers and models are expected to increase as well.



Figure 4 Two Case IH half-length modules staged together and being loaded into a module truck.

The considerations for selection between those offerings are similar to those of conventional module covers. Some individuals have tried to place two 16-foot modules end to end and use a 32-foot cover over both, but this practice is discouraged. **Figure 4** illustrates two half-length modules staged together, with one being loaded into a module truck.

John Deere Round Modules

The John Deere 7760 cotton picker forms round modules that are fully enclosed on the circumference by a specially engineered polyethylene film that protects the cotton while also providing a compressive force to maintain the module density. John Deere sells the cover materials; and, at the time of this writing, no third-party options are available. The film materials are sized to lap up a couple of inches on the ends of the round module so that water flowing on the ground surface cannot enter the seed cotton. **Figure 5** shows round modules with the plastic film wrapped onto the end.



***Figure 5** Deere round modules stored for transportation to the gin. Note the yellow plastic wrap forms a lip on the ends of the modules.*



What is at Risk When Seed Cotton is Stored?

The negative impact of weathering on seed cotton is well recognized. Studies have shown changes in color when seed cotton moisture is increased. Curley, et al. (1987) found that most of the coloring effect was due to yellowing. The yellowing was primarily affected by moisture content, days stored, average air temperature during storage and initial temperature of the cotton module.

Moisture contents above 14 percent moisture sharply increased yellowing. As seed cotton moisture increased from 13 to 16 percent, there was a marked decrease in seed germination, and for seed cotton moisture contents above 16 percent, the seed would not germinate. Although increased levels of seed moisture caused a slight reduction in percent oil, there was negligible effect on oil quality index and percent oil as affected by seed cotton moisture content or other storage variables.

Damaged Module Covers

In practice, module covers are sometimes considered usable as long as they don't have large rips or tears in the surface. However, breakdown of the water-resistant coating can seriously degrade protection of the seed cotton. Used module covers were obtained from gin inventories and tested under laboratory conditions at Texas A&M University. The covers were evaluated on a light table and categorized based on the condition and number of visible pinholes. Samples were exposed to simulated rainfall in a standardized test, and the amount of water penetrating the cover samples was measured. The water penetration increased from a near zero level with new covers to an excessive amount for those covers rated as abused.

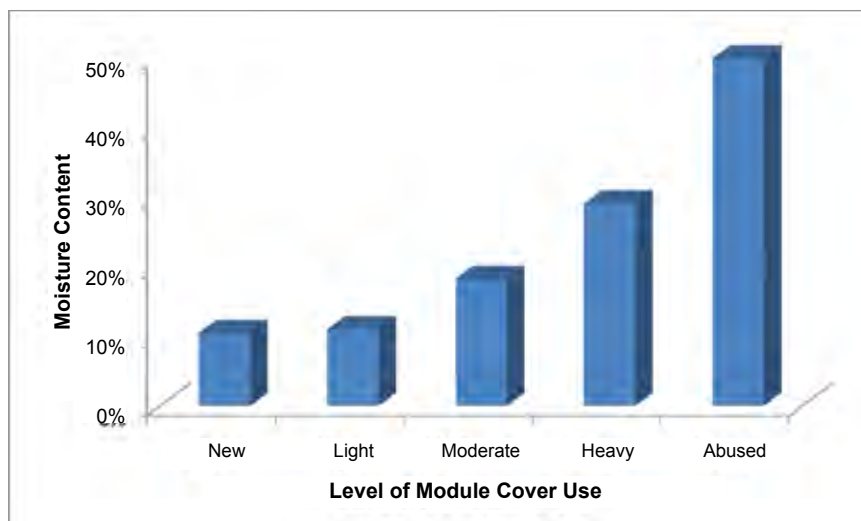


Figure 6 Chart showing the change in moisture content of the top two feet of seed cotton in a module with module covers of differing use levels. This analysis assumed seed cotton initial moisture content of 10%.

Figure 6 shows how the water penetration rates would affect the moisture content of the top two feet of a module during a four-hour rainstorm. The moisture content of the cotton was assumed to be 10% prior to the rainfall. The chart illustrates that even a moderately used cover (one that typically would be considered “ok”) will allow the moisture content to increase to levels that will cause grade reductions.

Effects of Poor Protection

The impact of poorly protected seed cotton modules can be observed in the gin when modules are exposed to significant rainfall. In the 2004 harvest season on the Texas High Plains, a period of good harvest weather was followed by several days of rain with no wind. Large numbers of modules were formed prior to the weather event, and were exposed to the weather while stored in the fields. This situation allowed the comparison of lint grades and ginning performance for modules formed and ginned before the weather event to those formed before the weather but ginned afterward (Simpson and Searcy, 2005).

Prior to ginning, observations were made by gin personnel to evaluate individual modules for shape (good or poor) and the ages of the cover used (3 years or less = “good,” more than 3 years = “poor”). The three-year age was a rough indicator of the cover’s ability to resist moisture penetration. A module shape was judged as good if the module was full sized and had a flat- to crowned-top surface. With these assessments of the module shape and cover quality, the impact of weathering for various conditions was evaluated.

With a total of 137 modules and 1967 bales observed, the study provided a “real world” assessment of the economic impact of module protection practices.

The study found that both growers and the ginner experienced significant economic losses due to poor seed cotton protection. **Figure 7** shows how the average loan value of the modules in each protection classification was changed compared to the modules of the

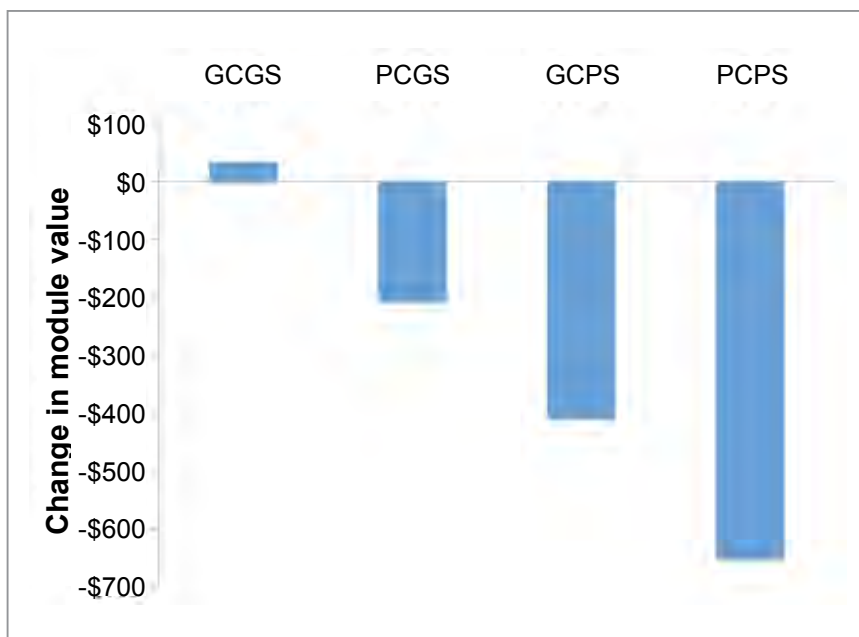


Figure 7 Change in lint value for modules with different protection conditions. These values are compared to similar modules ginned before the rainfall event. (GC – good cover, PC – poor cover, GS – good shape, PS – poor shape)

same cotton variety ginned prior to the rainfall event. The changes in lint value were due to reduced color grades.

Figure 8 shows the change in the yellowing portion of the color grade. The amount of yellowing of cotton increases from white (no or minimum yellowing) to light spot to spotted and to tinged (greater yellowing). When stripped and ginned before the rainstorm (SGBR) nearly all bales were graded as white. Bales from modules ginned after the storm, but with a good cover and a good shape (GCGS), retained the same high grade.

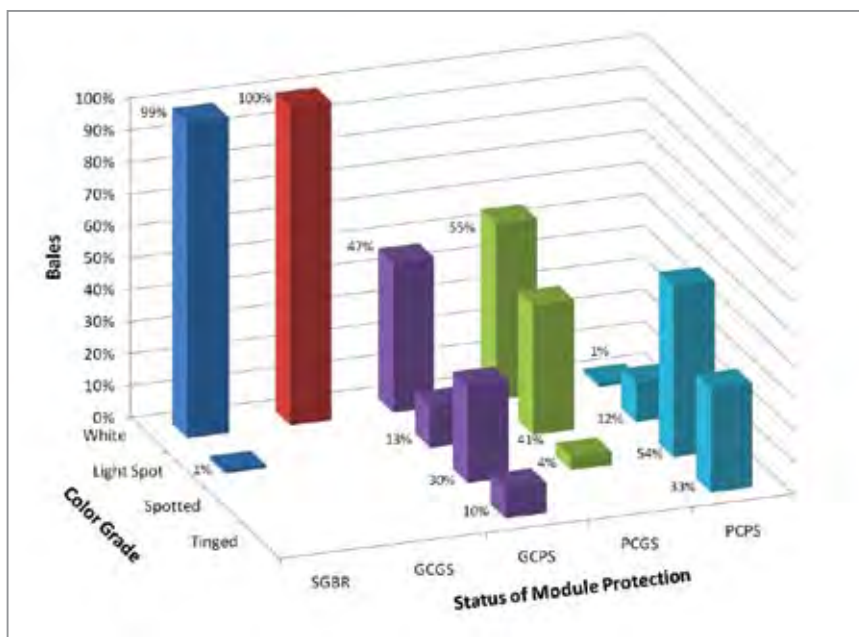


Figure 8 This chart illustrates the impact of module shape and cover quality on the color grade of cotton lint. (SGBR – stripped and ginned before rain, GC – good cover, GS – good shape, PC – poor cover, PS – poor shape)

In various conditions of poor cover (PC) or poor shape (PS), the color degraded to spotted or tinged. Modules with both poor shape and a poor cover (PCPS) caused 99% of the grades to be reduced due to increased yellowness. In well-formed modules with good quality covers, there was no change in lint grade and value between those ginned before and after the weather event. When comparing the total module value to those with no rain exposure, building a well-formed module prevented about \$200 loss, and using a high-quality cover prevented a loss of about \$400. These losses are completely avoidable with adequate protection of the seed cotton.

Further Loss of Potential Profits

In addition to the loss of value associated with reduced lint color grades, the growers also lost potential profit from a reduced gin turnout due to poor module covers. Table 1 shows the impact for the producer and the ginner of the different storage conditions. The well-formed modules with good-quality covers had no significant difference in turnout from the modules ginned before the storm. Poor shape and poor cover quality reduced the gin turnout up to 8 percent compared to the best condition. In addition, the wet cotton from the poorly protected modules also dramatically affected the productivity of the gin, causing an increase in ginning costs. Lost profit was not

confined to the grower. Ginning high-moisture cotton reduced gin productivity and increased energy required for drying. Both growers and ginners have an interest in proper protection of seed cotton, and good practices can ensure highest profit and quality.

Table 1 Influence of module shape and cover condition on lint turnout and ginning rate.

Condition	No. Modules Observed	Turnout (%)	Gin Productivity (Bale/hour)
<i>Stripped, Ginned Before Rain</i>	14	34.6	49.1
<i>Good Cover, Good Shape</i>	42	34.0	42.4
<i>Good Cover, Poor Shape</i>	40	31.4	34.3
<i>Poor Cover, Good Shape</i>	27	26.5	29.0
<i>Poor Cover, Poor Shape</i>	14	26.2	18.6

Forming and Covering Conventional Modules

Maximum seed cotton protection during storage is related to module site selection, along with construction and covering the module to prevent water penetration. The module building sites should be on well-drained areas such as turn rows or field roads (Figure 9).

Under wet conditions, low areas will collect water and saturate the bottom layer of the module, causing deterioration of seed cotton. The site should be smooth and firm, free of rocks, clods, and vegetation such as cotton stalks and grass. Do not build modules on stalks or tall vegetation, as they will be picked up with the module in the loading process. Ginning may not remove all foreign matter, resulting in contaminated lint and reduced lint grades. The site should be easily accessible by the harvester or boll buggy and clear of overhead obstructions such as utility lines or trees. If possible, the site should be accessible to module trucks during wet weather. If possible, modules should be built in an area away from heavily traveled roads, thus away from possible sources of fire and vandalism.

The previous discussion has shown that properly built modules, along with good module covers, will maintain seed cotton quality prior to ginning. Uniform packing of the module during building is important in a properly made module. This requires coordination of the module operator and the operator of the boll buggy or harvester. Cotton should be dumped uniformly in even layers of the module builder to minimize the amount of leveling by the trumper (Figure 10a and Figure 10b). Harvester and module builders equipped with metering systems can spread cotton the length of the builder, resulting in faster unloading with

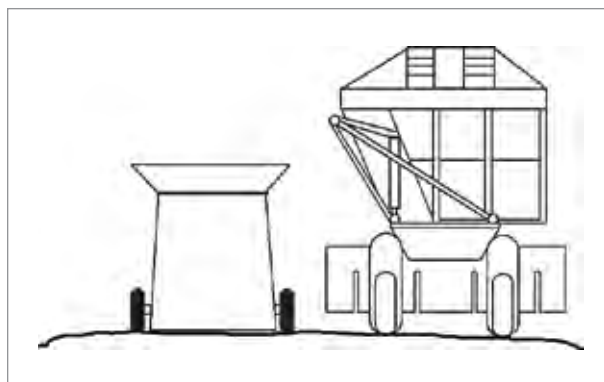


Figure 9 A well-drained site clear of weeds and cotton stalks and easily accessible by boll buggy or harvester should be selected to build modules.

Figure 10 Procedures for forming a seed cotton module in a module builder.

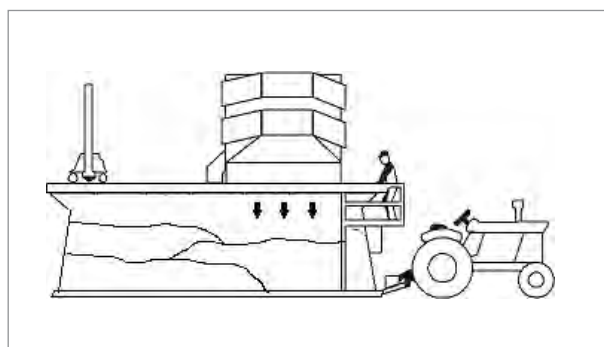


Figure 10a Initial dumps should alternate ends of the chamber until the seed cotton level rises to the point where the cotton can be compacted.

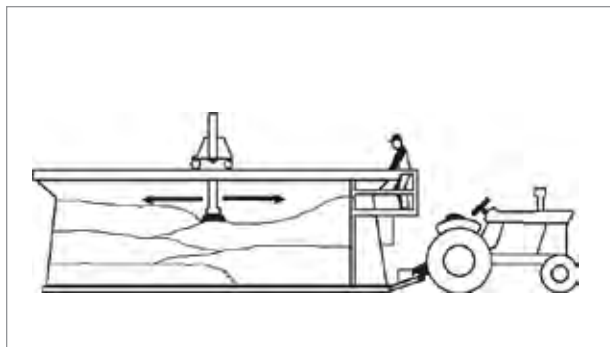


Figure 10b As more cotton is added to the chamber, the tramper should be used to move cotton along the length of the chamber to achieve uniform loading.

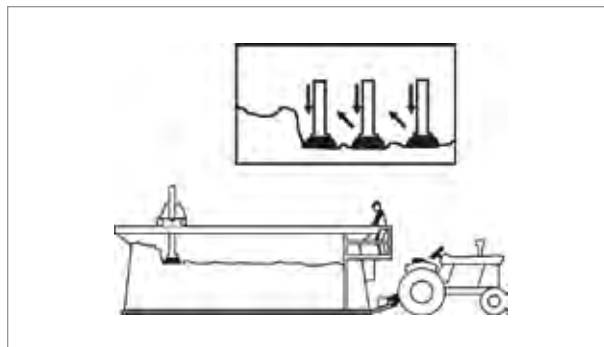


Figure 10c The cotton should be compressed with a series of actions with the tramper to uniformly pack the entire chamber.

less spillage. Leveling and tramping should begin immediately after initial dumps into the module builder and continue until the module is completed. After leveling, tramping is started by lowering the tramper until full weight of the builder is on the cotton. The tramper is raised and then moved laterally 14 to 16 inches and compression of the seed cotton is repeated (**Figure 10c**).

Module Compacting

Packing should be continuous until the module is finished. Ends of the module should be packed two to three times more than the center to prevent the ends from sloughing off when the builder is removed. The tighter the module is compacted, the better it sheds rainfall on the sides and the less seed cotton is lost during storage, loading and hauling. Low-moisture cotton will require more tramping or compressing as the cotton is more “springy” and will not hold the compressed form like higher moisture cotton.

Removing Modules

To remove the completed module from the builder, the rear door is opened fully, and the builder raised on the transport wheels (**Figure 11**). Take caution when opening the rear door, as the operator will not be able to see the area behind the door. Make sure any

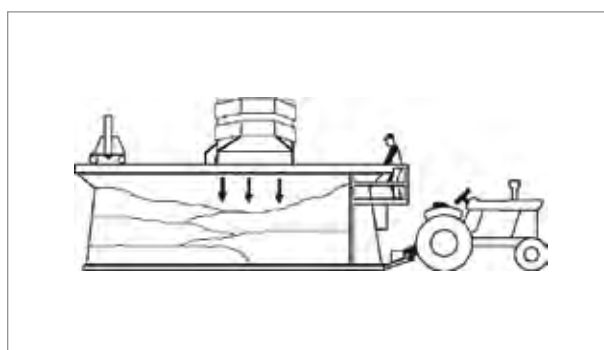


Figure 10d When the module is nearly completed, move cotton to the ends to provide space for the last dump and to form solid ends.

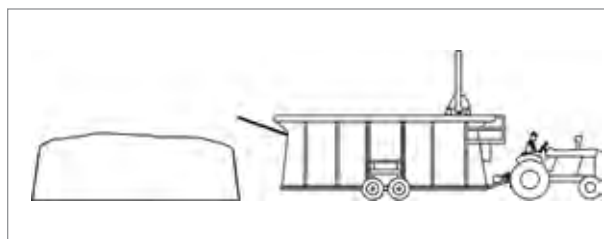


Figure 11 Upon completion of the cotton module, the rear door is opened, the module raised on the transport wheels and the tractor is driven forward to move the builder off the module and to the location for the next module.

support workers in the area are in view before opening the door. Because of the tapered form of the module, when the builder is raised, the tractor can easily pull the builder forward without damaging the module. The tractor must be driven straight forward. Attempting to turn the tractor while the builder is over any portion of the module likely will result in damage to the module and/or builder. The completed module should be shaped like a loaf of bread, the top rounded from side to side and ends of the module lower than the center of the module (Figure 12a). Depressions in the module surface will cause water to collect, likely resulting in wet cotton (Figure 12b).



Figure 12a



Figure 12b

Figure 12 A well-shaped module will have a “bread loaf” type shape that causes water to quickly flow off the cover. Image a) shows a desirable shape, while image b) shows a module with depressions that pond water on the surface. Even in a high-quality cover, this collected water will eventually make its way into the cotton.

Instructions to Covering Crew

Rejecting Worn or Damaged Covers

When picking up previously used covers from the gin or other supplier, the crew should have authority to reject covers that appear worn or damaged. Since damage may not be apparent when covers are rolled for storage, rejection of poor condition covers should also be authorized in the field. After unrolling a cover, if it appears to be in bad shape, it should be set aside and another cover used. These practices by the covering crew should be discussed with your gin manager or supplier.

Module Covering Methods

Covering modules can be a difficult task, especially when the wind is blowing. Crews use various methods. Some will unroll the cover on top of the module while the module is still in the builder, others will attach the cover to the rear door of the builder so that the cover is dragged over the module as the builder is moved off, and others will use a ladder to climb on top of a free-standing module to spread the cover. A preferred method is to use the module builder door to pull the cover over the module while moving the builder off the module (**Figure 13**). This method avoids the need for a worker to be on top of the module, but requires covering the module immediately at the time of building. A covering crew that works independent of the module forming will have to use ladders to place the cover on the top of the larger modules.



Figure 13 Covering a module by using the builder to pull the cover over the module. The front edge of the cover is attached temporarily to the door as the builder is driven forward.

Whichever method is used, avoid walking on the cover after it is spread on top of a module. Walking on the cover after installation can cause puddles and water penetration even if the cover is in excellent condition. The cover should be pulled as low as possible on the module on both ends. Lower attachment points will help to avoid standing water on the surface and make the cover less susceptible to wind damage or removal. When tightening the cover onto the module, do not tie hard knots in the belt or rope. If using tie-downs on the side of the cover, use module twine, not plastic or baler twine.

Safety Issues for Cover Crews

- Avoid walking on top of modules. There is a high potential for falls. A better method of applying a cover is to pull the cover on when moving the builder off the module. Attach the cover to the rear door of the module builder prior to opening with spring-loaded clips. The clips allow separation of the module cover from the door after it is pulled on completely, avoiding rips.
- During windy conditions, extra personnel may be required to prevent the cover from being blown off while the cover is being installed. Covers should not be installed in winds greater than 20 mph.

Case IH Half-Length Modules

Forming and Staging

The Case IH Module Express cotton picker automatically forms the half-length modules with minimal action on the part of the operator. The operator's manual provided by the manufacturer provides guidance on the operation of the module forming system. Each operator should read, understand and follow those instructions.



Unloading the Module

The primary activity for the operator regarding the module is to decide when to unload it. The instrument console provides an indicator of the size of the module being formed as a percentage of the recommended size. In most cases, the module size will not be 100 percent of recommended size as the picker reaches the turn row. For this reason, the operator must decide to unload a less than full-sized module, or to continue picking and have to deadhead back to the turn row when the module is complete. These decisions can have a significant influence on the operating efficiency of the harvester. For more information on unloading half-size modules, see “The Spindle Type Cotton Harvester” publication.

Staging Two Modules Together

When the modules are unloaded, typically on a turn-row, they must be staged properly so that they can be picked up by a module truck. While some operators have tried to stage two modules together, this often means driving to the location of a previously unloaded module. Staging together is not a requirement, as module truck drivers can pick up a single half-length module, drive to the next module and pick it up as well. These separate actions require a higher level of skill on the part of the module truck driver, and so problems with module damage can occur with inexperienced drivers. The following practices are recommended when unloading and preparing modules for transport:

- Modules should be unloaded from the harvester only in well-drained areas of bare soil, such as turn-rows. Avoid placing the module on cotton stalks or grassy areas to minimize

contamination that might be picked up with the module by the truck. If possible, avoid areas where the module truck cannot access the modules if rain occurs.

- When unloading modules from the Case IH cotton picker, avoid overhead obstructions that might be contacted when the chamber is raised. If cover crews or other workers are in the area, make sure all personnel are in view or someone signals “all clear” before unloading the module. This is especially true when staging a second module near another.



Figure 14 Half-length module unloaded too close to another module. Notice how the first module is pushed backward at the top. If this occurs before the module is covered, cotton will often fall off the back of the first module. Note also the offset between the two modules. This offset will make picking up the two modules together more difficult.

- If staging modules together for pickup by a module truck, allow 12-18 inches between modules. If closer, the angle of the second module coming down the unloading ramp will push the first module out of shape and possibly knock cotton onto the ground. **Figure 14** shows a module unloaded too close to another module. Module staged together must also be closely aligned to allow the truck to pick up both in a single loading action.
- When cotton falls from the top of the module during unloading, it should be picked up and thrown on top of the module prior to covering, not stuffed between the modules. While this loose cotton between the modules will be picked up by the module truck, it will not be protected by the module cover during storage and any rainfall will cause it to become a wet mass that contacts both modules.

Covering Half-Length Modules

The half-length modules require a 16-foot-long cover similar to conventional covers in manufacture. Multiple manufacturers offer



Figure 15 Installing a cover on a Case IH half-length module.



16-foot-long covers, and the considerations for selection between those offerings are similar to those of conventional module covers. Some individuals have tried to place two 16-foot modules end to end and use a 32-foot cover over both, but this practice is discouraged, as it often will tear the large cover when the two modules shift independently.

Installing Half-Length Module Covers

The practices used for installing conventional covers are also appropriate for the half-length modules. Because of the smaller size, and often shorter modules, half-length covers are easier to apply. Because of the auger mechanism used in the compression chamber of the Module Express picker, the half-length modules have a tendency to have depressions along the length of the module that can collect water during storage. To minimize the potential for water collection, it is important to pull the cover down over the module as much as possible. A loose top surface is more likely to collect water that could potentially penetrate into the seed cotton.



John Deere Round Modules

Forming and Staging

The John Deere 7760 forms round modules, using a mechanism similar to that of a round hay baler. The operation of the module-forming mechanism is highly automated, requiring minimal operator interaction. The round modules are covered with an engineered polyethylene film that both protects the seed cotton and provides compressive force to maintain the module density. The module-forming control system handles the wrapping of the modules; and, when wrapping is completed, the module is ejected onto the carrier at the rear of the machine, as shown in **Figure 16**.



Figure 16 A John Deere 7760 cotton picker carrying a finished round module while harvest continues and the next module is being formed.

The primary action of the operator regarding the modules is to decide when to drop the module being carried. Typically, the finished module is carried until it can be dropped on a turn-row. If the yield is very high, or the row lengths are long, it may be necessary to drop the modules in the middle of the field. This action has no impact on the operation of the picker, but stalks may puncture or tear the plastic wrap.

Avoiding Module Rolling

Because of the round shape of the modules, there is a concern about dropping the modules on sloping ground. When the carrier is lowered for unloading, the modules do roll onto the ground. Typically, there is enough flexing of the module shape that the rolling stops very quickly. However, there is a potential for continued rolling if the module were dropped when the picker is headed up a steep slope. In rolling terrain, the operator should drop the modules only when the picker is oriented across the slope to prevent excessive rolling.

Transporting Round Modules

The round modules can be transported to the gin in conventional module trucks or on semi-trailers. The modules must be picked up where they were dropped in the field, and staged together for pickup, four for a module truck and six for a semi-trailer. The staging can be done using several

different implements. The most common system is to use a set of forks with hydraulically controlled spacing mounted on the three-point hitch of a tractor (Figure 17). Other devices include a mast-type mounted implement that holds the module with the axis parallel to the tractor rear axle or a set of forks on a front-end loader. Because the round modules can weigh over 6,000 lbs., a large tractor is required for staging. The following practices are recommended when unloading and preparing modules for transport:

- Modules should be staged only in well-drained areas of bare soil, such as turn-rows. If the soil is wet, wheel slip by the truck can cause the chains to tear the plastic wrap. Avoid placing the module on cotton stalks, as the movement of the modules on the stalks can puncture the plastic wrap. If possible, avoid staging in areas where the truck cannot access the modules if rain occurs.
- When staging round modules together for transport or for storage at the gin, lift the module 12 inches or more above the ground. A lower position can result in stalks tearing the exposed wrap on the bottom.
- When placing modules together for transport, a 4- to 8-inch space should be placed between modules (Figure 18). Do not allow module ends to touch, as this will cause water to enter the



Figure 17 Carrying a round module with a three-point hitch attachment. The module is being staged for transport to the gin.



Figure 18 Staging of round modules for transport in conventional module trucks should be done in sets of four. A gap of four to eight inches should be placed between round modules to prevent damage of the wrap when loading (inset). (Photos by Alan Brashears.)



modules rather than to run off down the ends. The modules should be aligned so that the centerlines are within a +/- five-inch band. If not properly aligned, the wrap may be damaged by the sidewalls of the module truck.

- Stage round modules for transport end-to-end rather than side to side.
- Module trucks used to load and transport round modules should be fitted with chains that have rounded cleats that will not puncture the plastic wrap.

Module Wrap Protection and Handling

The plastic wrap typically performs well in preventing moisture from entering the seed cotton. The open ends of the modules will shed rainwater, provided the ends are not touching. Modules too close together will hold water between the ends, resulting in wet cotton with the usual potential for reduced-quality grades. When intact, the wrap will shed water on the circumference of the module.

Punctures and tears in the wrap can occur and will allow degradation of the seed cotton if not repaired. Tears can be covered with a water-resistant tape, such as lint bale repair tape. A common problem is that the adhesive at the end of the wrap gives way after weathering, resulting in loose ends. John Deere recommends reattaching the loose end with 3M 90 spray adhesive or lint bale repair tape. Wrap damage should be repaired before transport, as the loading/unloading actions can make damage more serious. The inside walls of the module truck must be free of burrs or edges that could catch and tear the wrap during loading.

Module Covers

Two factors are needed to make the modern cotton packaging, storage and transport system effective: a well-formed module that resists moisture collection and a cover that prevents both moisture penetration and wind loss. These principles apply for both conventional modules and modules formed by the on-board modeling harvesters.

For on-board harvester modules, the shape of the module is controlled by the machine, but the producer/operator must still be concerned with the integrity of the protective cover.



Module Tarp Construction

From early days of forming seed cotton modules, protection of the module was recognized as necessary while waiting to be ginned. Canvas was used to cover the earliest modules, and the importance of that protection was demonstrated by the development of a standard for cotton modules that included the performance and design of canvas covers (ASAE, 1997). While modern covers are no longer made of canvas, the importance of preventing moisture from entering the seed cotton is still recognized.

Top Surface Materials

Covers for conventional modules are manufactured from a variety of materials that resist water penetration. All modern covers are made of a plastic material (typically polyethylene), either as a film or woven from tapes of differing sizes. The woven fabrics may be coated on either one or both sides, and the coatings can be polyethylene or polyvinyl chloride.



UV Inhibitors

All module covers should have UV-inhibiting chemicals incorporated into the cover material. While the type and quantity are often not disclosed to buyers, butylated hydroxytoluene (BHT) stabilizers should be avoided because they tend to turn seed cotton yellow when they come in contact with the cotton. High levels of UV-light stabilizers are recommended for all regions of the Cotton Belt. The three primary types of module cover materials available today are:

- woven polyethylene with double coated polyethylene laminate (usually called “poly” covers),
- polyethylene terephthalate (PET) scrim with double-coated polyvinyl chloride film laminate (usually called “vinyl” covers) and
- polyethylene film.

Top Surface Factors

The top surface can be formed in various ways, depending on the manufacturer. Most covers manufactured today do not have seams in the top surface, because of the potential for leaks. Any seams in the top surface of laminated, coated fabrics should be heat sealed to minimize leakage. Manufacturers often offer a range of colors for the top surface. Color does not make a difference in performance in most regions of the Cotton Belt. The exception would be south Texas, where the more intense solar radiation in the summer harvest period would encourage the use of lighter colored tops.

Mesh Netting

Plastic mesh netting is sometimes used instead of module covers to limit wind losses in the more arid cotton producing areas, as it is assumed that the modules will not be exposed to rain. The netting primarily serves to prevent loss of seed cotton during periods of high winds, but provides no protection from water. Most gin managers prefer the mesh netting not to be used, as the modules are exposed to possible moisture damage. The netting is also difficult to remove at the module feeder and presents a disposal problem for the gin.

Skirts

Skirts (the vertical portion of the cover extending down the side of the module) are available in a variety of forms. Module skirts can be fitted or open-ended. The material on the ends of the cover is typically the same as the top surface. The skirts can be made of coated fabric (typically of a lighter weight than the top) or a mesh fabric. The mesh is preferred in regions where seed cotton moisture and cool morning air can cause condensation on the underside of the

cover. With the mesh sides, air flow is enhanced across the module top to dry and remove the moisture. Manufacturers offer the side skirts in both straight and V shapes. The V shape skirt is considered by some users to be better than the straight sided skirt because they tend to stay on the modules better during high wind conditions.

Belts and Tie-Down Loops

Module covers include a method for firmly attaching the cover to the module. Ropes and belts are the common methods of holding module covers on the modules. They are enclosed in sleeves sewn around the bottom of the cover skirt that allows the rope or belt to slip as they are pulled tight. Adequate tension on the rope or belt is necessary to keep the cover on the module during windy conditions.

Some cover designs have two tensioning points: at the bottom of the skirt and midway up the skirt. Flat belts normally utilize buckles for maintaining tension (**Figure 19**). Ropes are provided with rings that can be used to tie off the tension. It is important that the knots for ropes and buckles for belts are easily untied and unbuckled and do not need to be cut for removal. Use only slip knots when tying ropes. When the module is exposed to wind, the cover will raise off the module, tightening the belt or rope, which will cause any knots to become extremely tight and compressed. In this situation, gin workers will typically cut the belt or rope in the interest of saving time. Properly tied knots and buckled belts will prevent rope and belt repairs that might hinder slippage through the sleeves and undesirable knots or ties not easily untied or unbuckled at the gin. The extra length of rope or belt remaining after tying or belting should be placed inside the module cover to prevent entangling in the module truck or module feeder.



Figure 19 A belt used to tension the strap at the lower edge of a module cover. Belts should be in good condition, and knots should not be substituted for a damaged buckle. Set aside damaged covers and use a good condition cover.

High Wind Situations

The belt or rope alone may not be adequate to keep the cover on the module. In very high wind situations, additional ties over the top of the module can be used. Some cover designs include tie-down points (such as loops or grommets) in an effort to prevent high winds from tearing the fabric, or removing the cover from the module completely. These additional ties are either placed under the module before it is formed, or forced through the middle of the module when the cover is applied.



Figure 20 Baling twine and other plastic materials should not be used as tie-downs. Module tape can be used to hold down covers in high wind regions. The tape should be placed under the module before it is formed, and not through the module. (Photo by Alan Brashears.)

Safety tip

Don't place hands or arms under a raised module builder. This is especially important when placing tarp ties under the module builder prior to building a new module. Use a stick or rod to push the strap from one side to the other.

Figure 20 shows a tie-down under the module. Placing module tape (not baling twine or similar material!) under the modules is the recommended method. Driving a tie-down tape through the module requires a great deal of force and has the potential for both personal injury and placing contaminants into the seed cotton.

Labels

All module covers should have labels that indicate the manufacturer, address and phone number, model name or number, the date the cover was manufactured and other pertinent information. An intact label is critical for proper management of an inventory of module covers, as managers commonly use years in service to determine when a cover should be discarded. Never intentionally remove labels from covers.

Cover Life and Management

Module covers have a limited life, and should not be used beyond that period. That life is limited by the damage that occurs to the cover, compromising its ability to resist water penetration. Damage can occur from multiple factors, and understanding the impact of the damage sources can aid in the management of an inventory of covers. As was shown earlier, even covers with moderate use can result in seed cotton moisture levels high enough to lose significant value.

Man-Made Damage

The most severe and obvious damage is often caused by workers handling, installing or removing the covers. Proper practices can avoid this damage. Following are practices that can minimize man-made damage.

- Refrain from excessive dragging and in particular dragging over areas with sharp and pointed objects.
- When hauling covers to the field, pay attention to where covers are placed. Always place covers on a clean, flat surface, free of sharp pointed objects.
- Refrain from walking on covers, either on a module or on the ground.
- Belts and ropes for tying down covers have a tendency to become abused during use. If the buckle or D rings fail, set the cover aside for repair and use another. Tying a hard knot in a belt will usually result in having to cut the belt at the gin, requiring a more expensive repair.
- After use, fold and roll the covers properly for easy handling and reuse on the next module.
- Store covers in dry enclosed areas free of rodents.
- Module covers should not be stored in a muddy condition.

Ultra-Violet Exposure

Prolonged exposure to UV rays causes a significant breakdown of the protective coating on module covers. This exposure increases with time (the number of days on a module in storage), and solar radiation intensity (more severe in the summer and early fall months). Significant UV exposure causes the coating to weaken and allows pinholes to form. Since this breakdown does not cause large defects, such as rips or large holes, covers are often kept in service well past the time when the coating is able to resist moisture penetration.

Figure 21 shows coating particles that have broken from the cover and fallen onto the seed cotton. These coating flakes are a potential form of contamination of the cotton. Covers should be thrown away well before a situation like this occurs.



Figure 21. Coating breakdown due to extended UV exposure can cause contamination of cotton lint. The blue color on the cotton is flakes of coating that have been caught in the lint.

Wind

Wind can have a significant effect on module covers in two ways. At lower speeds, wind causes the cover fabric to flap. Flapping causes the cover to bend and flex, resulting in a breakdown of the protective coating similar to that caused by exposure to UV rays. In fact, it is often not possible to distinguish which of these sources is the cause of cover damage. Since weather exposure includes both solar radiation and wind, both contribute to the gradual breakdown of the coating. When the wind is very high, the damage can be dramatic and catastrophic, such as when the base fabric of the cover rips along a seam or other stress points (Figure 22).



Figure 22. Seed cotton can be exposed to losses when high winds damage the cover. (Photo by Alan Brashears.)

Module exposure to wind varies greatly across the Cotton Belt. Wind concerns are not great in California and Arizona, but significant wind damage often occurs in the Texas High Plains and Oklahoma. Severe weather in the High Plains is often related to passing weather fronts that generate wind speeds greater than 50 mph. Such high winds cause intense strains on the module cover, which results in torn covers and broken tie-down straps. Complete removal of the tarp can result in seed cotton blowing off the module and wetting of the seed cotton in the module if rain also occurs.

The Texas Gulf Coast, Mid-South and the Southeast can be subject to long periods of high winds during hurricanes and tropical storms. These areas are also subject to long periods of rainfall that have resulted in significantly increased moisture in the module. It is best to build modules with the length of module parallel to the predominant wind direction.

Cover Performance

Weathering tests have shown a wide range of performance by module covers. Extended UV exposure has demonstrated that vinyl and film covers retain high moisture resistance after four years of summer months' exposure. The performance of coated, woven polyethylene covers has varied from high resistance (similar to the vinyl and film covers) to rapid degradation within a single season of exposure (Simpson and Searcy, 2008). Limited testing of cover samples in a wind tunnel has shown similar variability for the coated woven covers and high performance for the vinyl covers. The film cover does not perform well in high winds, as the stresses generated by the wind's force cause the film to rip.



Cost and Performance

Covers vary in price from approximately \$65 to \$125 each. As with many products, higher performing covers generally have a higher price. However, the cost of even the highest price cover is less than the lint value that was lost due to poor covers in the 2004 High Plains storm event. Vinyl covers generally have the highest cost, but perform consistently well in a wide range of conditions. They have the disadvantage of being significantly heavier than the other cover types.

Film covers are more moderately priced, lighter weight and most suitable for regions where high winds are not expected but significant rainfall occurs. Coated woven covers have the widest range of prices and performance. The better performing models are suitable for all regions of the Cotton Belt, but purchasers should ask for performance histories of the models when making purchasing decisions. No performance standard exists today that can be used to judge the relative performance of available covers. Information for making purchase decisions is available from the cover manufacturers.

Inspection and Repair of Covers

Inspection of covers should occur both in-season and at the end of the ginning season. Typically, covers are used on three to five modules per season, and each time a cover is removed from a module at the feeder, an inspection should occur. Typical practice is to lay the cover out on the floor near the feeder, fold it over to 1/3 of the width and roll it up using a powered or manual roller. Train feeder employees to observe the cover and look for larger defects such as rips, failed seams, or holes in the top surface and an inoperable belt or rope. If such defects exist, that cover should be placed in a "Do not use" pile to prevent that cover from going out onto another module. Those covers can be inspected for possible repair at the end of the season. Inspecting for pinholes and coating degradation is not feasible during the season because of the time required for an adequate assessment.

End of Season Inspection

Following the end of the ginning season, inspect the covers more thoroughly to determine if they are suitable for use in the next season. One simple means of determining which covers should be removed from the inventory is to use age as a determining factor. The manufacturing date shown on the label can be used to identify covers too old (a common age limit is three years) to be used again. Inspection and repair can be done by gin employees or by companies that specialize in cover inspection and repair. In addition to the larger defects that can be observed, the cover should be placed on a rack or light table that will allow light to pass through any pinholes in the coating.



Safety

Regardless of module type, safety should be high priority for all workers. Equipment manufacturers include extensive discussions of safe operating practices in the operator's manuals for their machines. All employees should read the operator's manual before working around the equipment, and safety guidelines should be followed. The following points are additional practices to avoid injury or death.

Forming and Covering Conventional Modules

- Train new operators on all phases of operating a module builder. This will include site selection, operation, safety, covering, and module handling.
- When hooking up a module builder to a tractor, keep hands away from the drawbar. Pinching and crushing of hands and fingers can result from sudden motions of the drawbar.
- Do not park module builder in the transport position without inserting safety pins to lock the wheels and prevent accidental lowering. The best practice is to lower the module builder onto the skids when not in use to prevent the possibility of someone crawling under module builder.
- Do not reach under a raised module builder. This is especially important for those who place tarp ties under the module builder prior to building a new module. Use a tool to transfer the tie from one side to the other.
- Never enter the module builder chamber while in operation.
- Make sure the tramper cylinder is lowered into the transport position when moving the module builder on roadways or around overhead obstructions. When the hydraulic cylinder is in the operating position, there is high potential for catching wires and tree limbs when moving the builder.
- Do not build modules near overhead obstructions. Always evaluate the area around the builder when selecting a location to form a module. Be aware of overhead obstructions that might interfere with boll buggies and harvesters dumping into the module builder.
- Ensure that there is clearance before opening and closing the module door. If the hydraulic valve opening and closing the door is located in a position where the area behind the module cannot be seen, a spotter should be used to ensure adequate clearance.
- Modules are not billboards. Mark modules only with necessary identifying marks, and only with approved module-marking materials.
- Do not walk around the top of module builder to clear material from a boll buggy or to move cotton into the chamber. Avoid situations where there is a high potential for falls.

- Workers should not enter the module chamber to unroll covers. Fatalities have occurred when the tramper was activated inadvertently.
- Do not smoke or use welding equipment around a module builder that contains cotton.

Handling Modules

- When unloading half-length modules from the Case IH cotton picker, avoid overhead obstructions that might be contacted when the chamber is raised. If cover crews or other workers are in the area, make sure all personnel are in view or someone signals “all clear” before unloading the module. This is especially true when staging a second module near another.
- When unloading round modules from a John Deere cotton picker, be aware of the slope when dropping off a module from the carrier. While the tendency for the round modules to roll is low, it is possible on steeper slopes.
- Do not allow personnel behind or in the bed of the module truck when loading modules.
- Module trucks are not to back up to the module feeder without direction from module feeder operator or other system to ensure area is clear of personnel. The module mover should be equipped with a back-up warning system to alert gin personnel of equipment moving backwards.
- Do not cross between modules while on feeder table to remove covers. Employees have been trapped between modules, resulting in loss of life. Loosen the cover on the loading end of the feeder, pull it to the end of the module and then off the side. This strategy will keep workers safely to the side of the modules.
- Do not get on the module floor unless feeder system is off and locked out.
- When using an automated roller for rolling tarps, the operator should have a dead man's foot switch to control the roller power. The rolls are a severe pinch point, and arms have been broken when caught in a powered roller.



References

ASAE. 1997. Cotton module builder and transport standard. ANSI/ASAE S392.1 JUL97. American Society of Agricultural and Biological Engineers, St. Joseph, Michigan.

Curley, R.G., B. Roberts, T. Kerby, C. Brooks and J. Knutson, 1987. "Effect of Seed Cotton Moisture Level and Storage Time on the Quality of Lint in Stored Modules." Proceedings, Beltwide Cotton Production Research Conferences, Dallas, Texas.

Simpson, S. L. and S. W. Searcy. 2005. The benefits of replacing used module covers. Proceedings of the Beltwide Cotton Conferences, New Orleans, Louisiana. pp. 3029-44.

Simpson, S. L. and S. W. Searcy. 2008. Module tarp performance in weathering tests. Proceedings of the Beltwide Cotton Conferences, Nashville, Tennessee. pp. 778-786.