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ENGINEERING & GINNING

Cotton Ginners Handbook – Packaging Lint Cotton

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ABSTRACT

Bale packaging is the final step in processing cotton at the gin. Bale packaging is critical to protecting and preserving the quality of the ginned lint during shipping and storage before consumption at the textile mill. Smooth operation of the bale press and associated systems is required for the efficient operation of the ginning plant. Properly shaped bales are important to the safe and efficient handling and storage of bales. The bale press, condenser, and hydraulic systems must be sized to match the design capacity of the ginning plant in order to maximize capacity. Bale presses may be designed to produce Universal Density bales or High Density bales, although only Universal Density bales are currently approved by USDA. Proper maintenance of the bale press and related systems translates into reduced downtime for the ginning plant. All bale packaging, including the bale covering and strapping or ties, must be approved by the Joint Cotton Industry Bale Packaging Committee in order for the bales to be eligible for collateral in the Commodity Credit Corporation loan program. This manuscript discusses the individual components of a cotton gin bale packaging system and settings to ensure the consistent production of uniform bales of cotton lint.

Bale packaging is the final step in processing cotton at the gin. The packaging system consists of a battery condenser, lint slide, lint feeder, tramper, bale press, and bale tying mechanism. This system may be supplemented with systems for bale conveying, weighing, and wrapping. The bale press consists of a frame, one or more hydraulic rams, and a hydraulic power system. Tying subsystems may be entirely manual, semiautomated, or fully automated.

Bale presses are described primarily by the density of the bale that they produce, such as universal density or high density. Universal density presses are the current U.S. standard. As of 2022 only universal density bales are approved by the USDA Commodity Credit Corporation (CCC) and Joint Cotton Industry Bale Packaging Committee (JCIBPC), as indicated in the Specifications for Cotton Bale Packaging Materials published by the National Cotton Council of America (NCC) (National Cotton Council, 2023). The JCIBPC is sponsored by the NCC and the National Council of Textile Organizations. Other descriptions include up-packing, down-packing (Fig. 1), fixed box, and door-less (Fig. 2). Regardless of description, they all package lint cotton in a most suitable way to be handled in trade channels and at the textile mills (McCaskill and Anthony, 1977).

Figure 1. Down-packing bale press (courtesy of Lummus AG).

Battery Condenser. Battery condensers have a slow-turning, screened or perforated metal-covered drum on which the ginned lint forms a batt. The batt is discharged between doffing rollers to the lint slide. Conveying air supplied by a vane-axial or high-volume centrifugal fans passes through the screen on the drum and discharges out one or both ends of the drum through air ducts. The discharged air then goes to dust abatement equipment and then into the atmosphere.

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Figure 2. Fixed-Box bale press (courtesy of Cherokee Fabrication).

The speed of the condenser drum should be adjusted to the capacity of the gin so that a smooth, solid batt is formed. If the drum runs too fast, breaks will occur in the batt; if too slow, the batt will be thick, causing high static pressure loss, choking due to lint building up on tags in lint flue (backlash) in a lint cleaner, and difficulty tramping lint cotton into the press box. The recommended condenser drum peripheral speed depends on screen drum diameter, effective drum surface open area and gin plant throughput. Refer to Figure 3 and Table 1 as guides to estimating the required speed of the condenser drum based on these three criteria. Be aware excessive drum speed can cause premature wear to seals, bearings, and drives. In Figure 3, "US" represents undershot condensers (Fig. 4), and "OS" represents overshot condensers (Fig. 5).

Use of a variable frequency drive (VFD) to adjust the operating speed of the battery condenser manually or automatically is recommended. The VFD can be preprogrammed with preset speeds based on the number of gin stands in operation at any one time. A more sophisticated yet proven scheme is to constantly vary the speed based upon actual plant throughput regardless of the number of gins in operation. In such a scenario it is essential to know the instantaneous operating rate of the gin plant.

Deviations in the airflow to the condenser will affect the lint flow. Lint flues that are bent or dented can affect the flow of air causing lint to not batt uniformly. Sheet metal deflectors can be used in lint flues to provide uniform distribution of the lint on the condenser drum so that the formation of big-ended bales, in which one end is larger than the other, is prevented. Foreign matter, lint tags, rivet heads, rust, or protrusions, can often cause deflection of the air current, resulting in uneven batts on the screen of the condenser.

Condensers in poor operating condition, flashings in bad condition, and non-uniform drum resistance due to accumulations on the screen may cause more cotton and air to be deflected to one end of the drum and thus may produce big-ended bales. Daily inspection of the condenser and its lint ducts and discharge ducts will reduce the number of poorly shaped bales. Battery

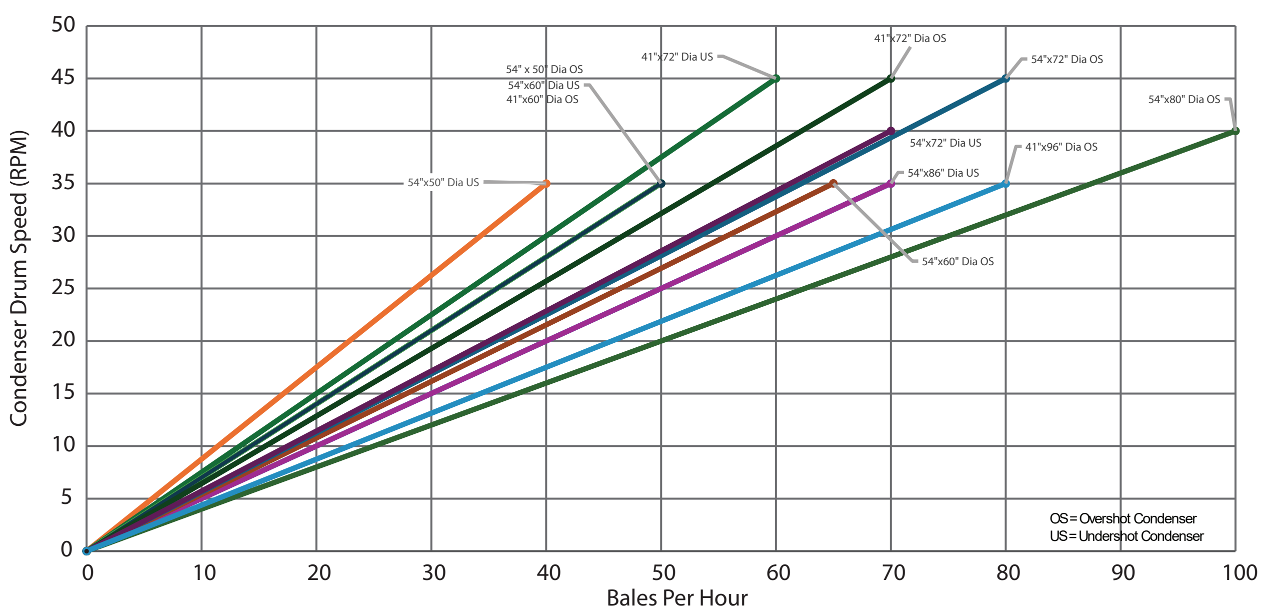

Figure 3. Condenser drum speed chart – RPM vs BPH (US – Undershot, OS – Overshot). Depends on screen drum diameter, effective drum surface open area, and gin plant throughput.

Table 1. Condenser drum speed selection table

BPH	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80
	---RPM---														
54” wide by 50” dia. US[z]	8.62	12.93	17.24	21.55	25.86	30.17[x]	34.48[x]	38.79[x]							
54” wide by 60” dia. US	7.18	10.77	14.36	17.95	21.54	25.13	28.72	32.31[x]	35.90[x]						
41” wide by 72” dia. US	7.97	10.64	15.96	19.51	23.51	27.50[x]	31.50[x]	35.49[x]	39.49[x]	43.48[x]					
54” wide by 72” dia. US	5.98	8.98	11.97	14.97	17.96	20.96	23.95	26.95[x]	29.94[x]	32.94[x]	35.93[x]				
54” wide by 86” dia. US	5.01	7.52	10.02	12.53	15.03	17.54	20.04	22.55[x]	25.05[x]	27.56[x]	30.06[x]				
54” wide by 50” dia. OS[y]	6.90	10.40	13.80	17.27	20.72	24.17	27.62	31.07[x]	34.52[x]	37.97[x]	41.42[x]				
41” wide by 60” dia. OS	7.57	11.35	15.14	18.92	22.71	26.49	30.28	34.06[x]	37.85[x]	41.63[x]	45.42[x]				
54” wide by 60” dia. OS	5.67	8.51	11.34	14.18	17.01	19.85	22.68	25.52	28.35	31.19[x]	34.02[x]	36.86[x]			
41” wide by 72” dia. OS	6.30	9.50	12.60	15.77	18.92	22.07	25.22	28.37[x]	31.52[x]	34.67[x]	37.78[x]	40.97[x]	44.12[x]		
54” wide by 72” dia. OS	4.79	7.18	9.58	11.97	14.37	16.76	19.16	21.55	23.95	26.34[x]	28.74[x]	31.13[x]	33.53[x]		
41” wide by 80” dia. OS	5.68	8.51	11.33	14.16	16.98	19.81	22.63	25.46[x]	28.28[x]	31.11[x]	33.93[x]	36.76[x]	39.58[x]	42.41[x]	
54” wide by 80” dia. OS	4.51	6.46	8.62	10.64	12.70	14.75	16.81	18.86	20.92	22.97	25.03[x]	27.08[x]	29.14[x]	31.19[x]	33.25[x]
41” wide by 96” dia. OS	4.73	7.09	9.44	11.80	14.15	16.51	18.86	21.22[x]	23.57[x]	25.93[x]	28.28[x]	30.64[x]	32.99[x]	35.35[x]	37.70[x]

[z]US, undershot designs

[y]OS, overshot designs

[x]Outside recommended operating speeds

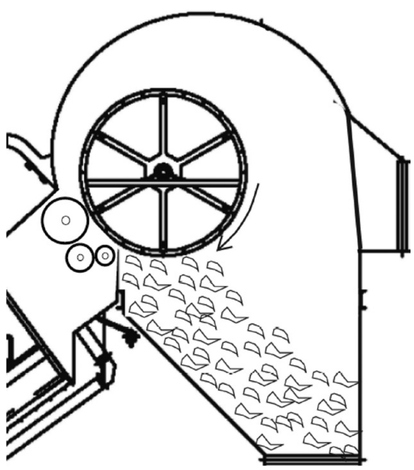

Figure 4. Undershot Battery Condenser.

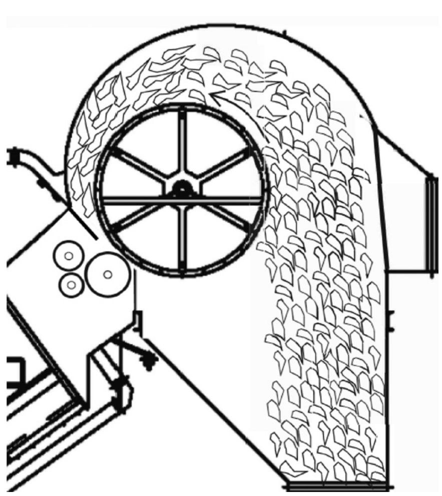

Figure 5. Overshot Battery Condenser.

condensers that discharge the conveying air from only one side are sensitive to the volume of airflow. Excess airflow will cause the batt to form on the drum nearest the air discharge and cause a big-ended bale. This problem can usually be corrected by reducing the air volume; however, installation of a larger condenser may be necessary. Use of a double-manifold condenser, which is like a lint cleaner condenser, would be another way to correct the problem of big-ended bales and would help produce a more uniform batt of cotton for the press. The upturned elbow in the lint duct nearest the battery condenser should be rectangular (Fig. 6), as should the remainder of the duct leading to the

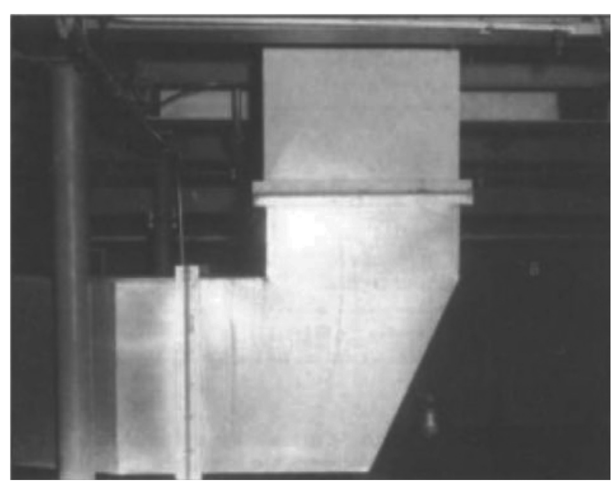

Figure 6. Typical rectangular elbow and duct near the battery condenser. The back of the elbow is inclined at 15° from vertical to improve lint distribution at the lint slide.

condenser. The back of the rectangular elbow should be inclined at a 15° angle to allow cotton to impact the elbow and be directed upward under the control of the air flow to the condenser drum. The condenser, its discharge duct and fan, and the lint ducts should be sized to properly handle the air volume discharged by the lint cleaners or gin stands that are to supply air to the system. The machinery manufacturers can provide air volume ratings for each item of equipment for proper system design.

Lint Slide. The lint slide is a sheet metal trough that connects the battery condenser to the lint feeder adjacent to the tramper. It has an inside width the same as the effective width of the battery condenser and is installed at an angle of 33 to 45° to ensure movement of the lint without rolling the batt. The length of the lint slide is based on the capacity of the ginning system and the time required to turn the press between bales. The rule of thumb is a minimum 20 ft of length with an additional 10 ft of length for every 15 bales per hour above 30 bales. There is a limit to how long a lint slide is practical, that being somewhere between 40 and 50 ft. Humidification systems pulling warm-moist air through the batt followed by compressing the batt between compression rollers, mitigate the need for excessively long lint slides by increasing the batts bulk density thus decreasing the volume of lint slide required. A long lint slide full of warm moisturized lint can be difficult to clean out if the gin plant must shut down for any length of time. It is best to run all the lint out of the slide prior to stopping the gin plant.

Lint Feeder. The lint feeder is a device for moving lint from the lint slide into the charging box of the press. There are two basic types of feeders and combinations thereof: (1) the lint feeder, often referred to as a belt feeder, and (2) the lint pusher which utilizes either a pneumatic or hydraulic cylinder in conjunction with a movable mechanical frame to push charges of lint into the tramping chamber. The lint feeder and pusher are often used in combination (Fig. 7) to feed trampers on high-capacity baling presses. Any one of these configurations should deposit lint into the charging box with a fast but gentle action, without breaking up the batt as it is received from the condenser. A smoother lint sample will result if this can be accomplished.

Tramper. The purpose of the tramper is to pack, or pre-press lint into the baler box prior to final compression. Most commercially available trampers are of the hydraulic type although some mechanical trampers are still in use in the U.S. today. Regardless of type, care should be taken to prevent contamination of lint

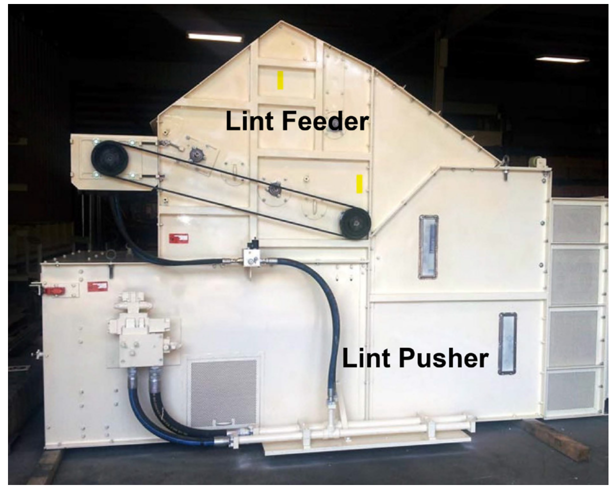

Figure 7. Lint feeder and lint pusher combination (courtesy of Cherokee Fabrication).

beneath the tramper by hydraulic fluid or grease from the tramper mechanism. Motors of 20 to 30 hp (15 to 22 kW) equipped with a fail-safe brake are usually used on mechanical trampers. Motors used on hydraulic trampers vary from 50 to 250 hp (37 to 186 kW), depending on design. With more gins being in the high and ultra-high-capacity ranges, the hydraulic tramper has become the work horse of the baling process. To keep up with demand modern trampers are often much faster, have a longer stroke and must be capable of handling larger charges of lint. The lint feeder and tramper should have a capacity greater than the gin plant capacity to be able to accommodate the extra lint accumulated in the lint slide during turning of the press boxes. Should the tramper get behind when the bale press is cycling to a new box, it should be able to catch up with the lint flow from the condenser well before the press box is filled. This will allow the bale weight control system to produce uniform bale weights. Varying bale weights not only have a very detrimental effect on the energy consumption of the press and the bale tie forces but also cause serious problems at the textile mills (Jones 1980).

The tramper must be able to keep up with the capacity of the ginning plant. At higher rates, a constant speed tramper will inevitably be forced to accept ever larger charges of lint. At some point this becomes untenable, affecting upstream flow of materials and undesirable bale weight variations. Some trampers are now supplied with control systems to vary stroke and speed of the tramper to compensate for such eventualities.

The hydraulic tramper is a relatively simple device with few moving parts. By the addition of sophisticated hydraulic and electronic controls, this simple device can be made to perform in extraordinary ways. The demands of the high and ultra-high-capacity gins can, however, put undue stress on the hydraulic tramper, stress in the form of excessive heat, contamination and extreme velocity that push the limits of current technology. These three subjects will be addressed in the bale press maintenance section of this chapter.

Bale Press. The only current approved bale type in the U.S. is Gin Universal Density (UD). The size and density of this bale and the Gin High Density (HD) bale is shown in Table 2.

Hydraulics. The hydraulic requirement to press lint cotton depends on the moisture content of the lint, the density to which the lint is to be pressed at final platen separation, and, to a lesser extent, the distribution of lint in the press box (Anthony and McCaskill, 1973). Typical densities encountered in the press box when pressing universal bales are shown in Table 3.

The force required to compress lint cotton to given densities at various moisture contents by a gin universal density press may be predicted from the equation:

$$\log F = 2.0929 - 0.0313m + 2.4469 \log P$$

Where, F = compressive force, lb (kg), m = lint wet basis moisture content, %, and P = density, lb/ft^3 (kg/m^3). The results of evaluating the prediction equation are shown in Figure 8 for a density range of 10 to 45 lb/ft^3 (160.2 to 720.8 kg/m^3) and lint moisture contents of 3%, 6%, and 9%. Hydraulic systems should be able to perform under the most adverse conditions anticipated; they should be able to produce heavy bales that are low in moisture and small in size.

Bale Ties for Gin Universal Density Bales. After the bale is compressed to a given density or press platen separation, ties are applied around the circumference of the bale to restrain the lint within prescribed dimensions. Bale ties are placed at pre-determined intervals along the length of the bale and are normally either polyethylene terephthalate (PET) plastic strap, high tensile steel wire or galvanized steel wire. Refer to the JCIBPC specifications for detailed and current requirements.

Most of the gin universal density bales are packaged with either six or eight PET plastic straps nestled in recess channels pre-formed in both sides of the bale to protect the strap during handling. The PET strap

Table 2. Types and dimensions of two most common bales produced at cotton gins

Bale type	Weight	Density	Length	Width	Thickness
	kg (lbs)	kg/m^3 (lb/ft^3)	--------------------------cm (in)--------------------------		
Gin Universal Density (UD)	217 (480)	448.5 (28)	140 (55)	53-56 (20-21)	66-76 (26-30)
Gin High Density (HD)	217 (480)	512.6 (32)	104 (41)	53-56 (20-21)	66-81 (26-32)

Table 3. Typical densities of bales from Gin Universal bale presses

		Density, kg/m^3 (lb/f^3) at bale weight, kg (lb) of given dimensions					
Bale Dimensions, cm (in)	Volume, m^3 (ft^3)	209 (460)	480 (218)	500 (227)	520 (236)	540 (245)	560 (254)
140x51x66 (55x20x26)[z]	.47 (16.6)	445 (27.8)	465 (29.0)	484 (30.2)	503 (31.4)	522 (32.6)	541 (33.8)
140x51x71 (55x20x28)	.50 (17.8)	413 (25.8)	431 (26.9)	450 (28.1)	468 (29.2)	485 (30.3)	503 (31.4)
140x51x76 (55x20x30)	.54 (19.1)	386 (24.1)	402 (25.1)	420 (26.2)	436 (27.2)	453 (28.3)	469 (29.3)
140x51x81 (55x20x32)	.58 (20.4)	362 (22.6)	378 (23.6)	392 (24.5)	408 (25.5)	424 (26.5)	441 (27.5)
140x51x86 (55x20x34)	.61 (21.6)	341 (21.3)	356 (22.2)	370 (23.1)	384 (24.0)	399 (24.9)	402 (25.9)
140x51x91 (55x20x36)	.65 (22.9)	322 (20.1)	335 (20.9)	349 (21.8)	364 (22.7)	378 (23.6)	391 (24.4)
140x53x66 (55x21x26)	.49 (17.4)	424 (26.5)	442 (27.6)	461 (28.8)	479 (29.9)	498 (31.1)	516 (32.2)
140x53x71 (55x21x28)	.53 (18.7)	394 (24.6)	410 (25.6)	428 (26.7)	445 (27.8)	463 (28.9)	479 (29.9)
140x53x76 (55x21x30)	.57 (20.1)	366 (22.9)	383 (23.9)	399 (24.9)	415 (25.9)	431 (26.9)	447 (27.9)
140x53x81 (55x21x32)	.61 (21.4)	344 (21.5)	359 (22.4)	375 (23.4)	389 (24.3)	404 (25.2)	420 (26.2)
140x53x86 (55x21x34)	.64 (22.7)	324 (20.2)	338 (21.1)	352 (22.0)	367 (22.9)	381 (23.8)	394 (24.6)
140x53x91 (55x21x36)	.68 (24.1)	306 (19.1)	319 (19.9)	333 (20.8)	346 (21.6)	359 (22.4)	373 (23.3)

Press box area is 137 x 51 cm = 6,987 cm2 or 0.6987 m2 (54 x 20 in = 1,080 in2 or 7.5 ft2)

[z]Suggested universal density bale size

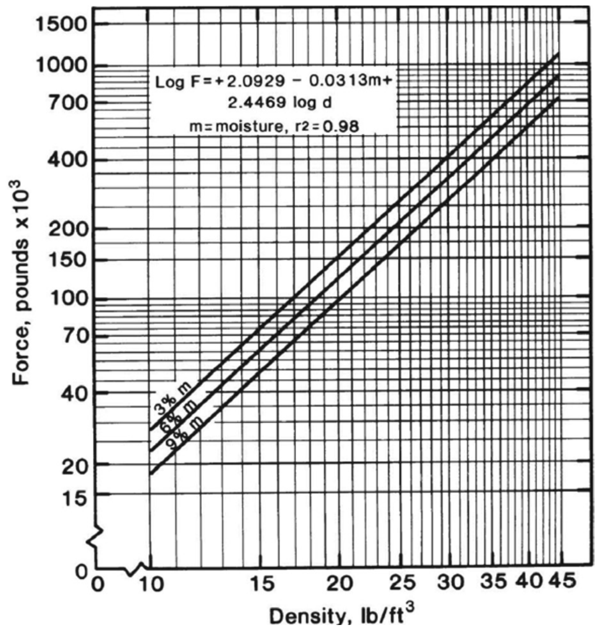

Figure 8. Predicted force to compress lint cotton in a gin universal density bale press at three moisture contents.

Table 4. Typical bale dimensions and tie lengths for universal density bale presses

Press box dimensions	Bale width	Bale thickness	Tie length
----------------------------- cm (in) -----------------------------			
51 x 137 (20 x 54)	53 (21)	66 (26)	213 (84)
51 x 137 (20 x 54)	53 (21)	71 (28)	224 (88)
51 x 137 (20 x 54)	53 (21)	76 (30)	234 (92)
51 x 137 (20 x 54)	53 (21)	81 (32)	244 (96)
51 x 137 (20 x 54)	53 (21)	86 (34)	254 (100)

joints are joined using an approved joining technology integrated into the strapping device. Strap material and joints must meet average and minimum break strength requirements as established by the JCIBPC specifications. Some gins continue to use pre-formed high-tensile wire ties to restrain their cotton bales although the number of gins using wire ties decreases every year. Specifications for wire material and joint strength are also found in the latest version of the JCIBPC specifications.

The weakest point of a bale tie is the connection. To increase the holding capacity of the tie, connections should be positioned near the top or bottom of the crown of the bale. The tie force is considerably less at that point, and the connection is protected because it tends to recess inside the fiber. Typical bale dimensions and tie lengths are shown in Table 4. Final densities for gin universal density bales are shown in Figure 9.

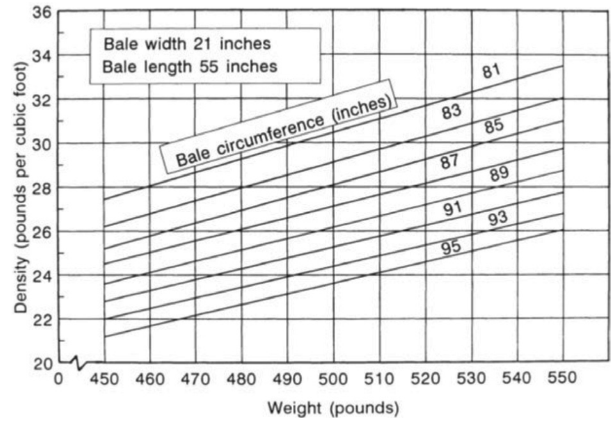

Figure 9. Relationship of density, net weight, and circumference for gin universal density bales 21 in wide and 55 in long.

Once the bale is released from the press, the lint cotton produces a resilient force on the bale ties. Excessive force exerted on the bale ties by the restrained cotton can cause the ties to break, and such breakage can cause contamination and handling problems. The force on each of the ties depends on its position on the bale (Fig. 10) primarily because lint can be distributed

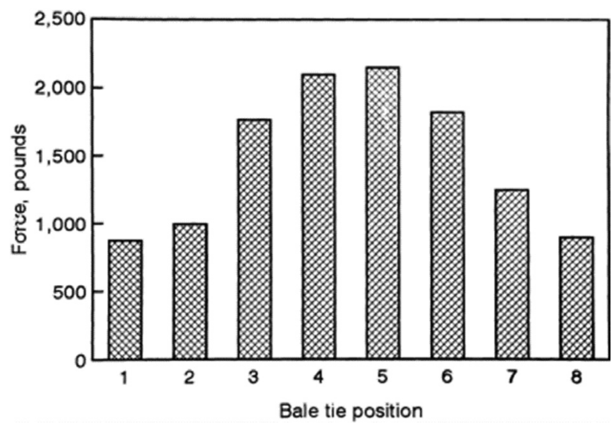

Figure 10. Nonuniform bale tie force distribution for one gin universal bale press.

non-uniformly within the bale. The bale tie with the greatest force exerted on it can have up to 15% to 20% of the total force exerted on all the ties of the bale. The force on the bale ties can also be affected by the platen separation to which a bale is pressed before applying the ties, the bale circumference at the tie after the bale is released from the press, and the lint moisture content. Figure 11 shows the effects of platen separation and bale circumference on maximum force per tie in 500-lb bales packaged at 5% lint moisture in a gin universal density press with eight ties. Maximum bale tie forces can be estimated as shown in the following example:

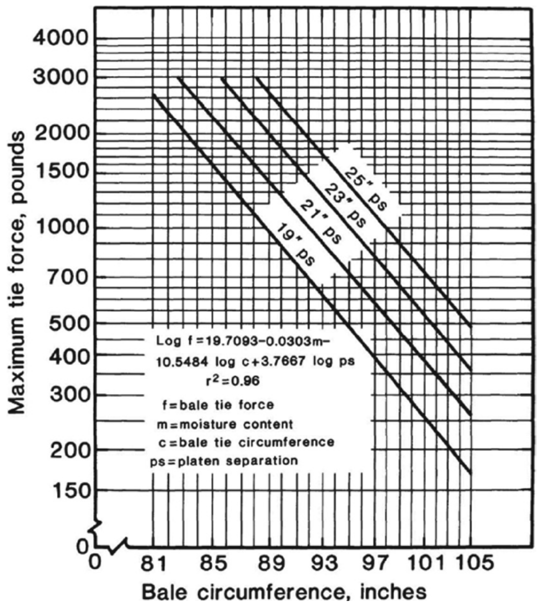

Figure 11. Average tie force (5% per tie) exerted by 500-Ib bales of upland cotton at 5% lint moisture. The equation predicts the accumulated force on eight ties, and the graph depicts 15% of that force as an estimate of the maximum force on a single tie.

EXAMPLE: Determine the maximum tie force exerted on one of eight equally spaced bale ties on a 500-lb (227-kg) bale packaged at 5% lint moisture in a gin universal press. The bale circumference at the tie is 85 in (216 cm).

SOLUTION: Refer to Figure 11 and note that the maximum tie force of 2,300 lb (10.2 kN) is exerted against the ties when the bale is compressed to a platen separation of 21 in (53 cm) and 1,600 lb (7.1 kN) when the bale is compressed to 19 in (48 cm). Note that the equation in Figure 11 calculates the total force exerted on all eight ties and that 15% of that force was used in the graph as an estimate of the maximum force on a single tie. For a 6-tie configuration use 20%.

In the above example, note that a change in platen separation of only 2 in (5.1 cm) without changing tie length resulted in a 30% reduction in maximum bale tie force. A 2 in (5.1 cm) change in platen separation also increases the press compression force required from 550,000 to 750,000 lb (2446.5 to 3336.2 kN). This 36% increase in required compression force would substantially increase press energy consumption. Therefore, other means of reducing tie breakage such as increasing moisture content of the lint (limited to 7.5% max) or pre-compressing lint cotton in the tramper chamber should be explored before resorting to reducing platen separation.

Variation in lint moisture and bale circumference (tie length) also has a pronounced effect on bale tie force. When a 500-lb (227-kg) bale at 5% lint moisture is compressed to a platen separation of 19 in (48.3 cm) in a gin universal density press, a maximum tie force of 1,700 (7.6) or 1,100 lb (4.9 kN) results, depending on whether restrained bale circumference is 84 (213.3) or 88 in (223.5 cm), respectively (Fig. 11). A 4 in (10.2 cm) increase in bale circumference results in a 30% reduction in bale tie force but only a 2 in (5.1 cm) change in bale thickness (Table 5).

Changes in maximum bale tie force for gin universal density bales due to changes in bale circumference, moisture, and platen separation are given in Table 5. Maximum bale tie force is about 15% less for cotton of 6% moisture than for cotton of 4% moisture.

Table 5. Changes in estimated maximum bale tie forces as platen separation, bale circumference and lint moisture change.

Platen separation	Bale circumference	Moisture content	8-tie Est. max. force	6-tie Est. max. force	Force decrease
------------------ cm (in)	------------------	----- % -----	--------------- kN (lb)	---------------	----- % -----
53 (21)	216 (85)	6	9.56 (2150)	12.75 (2867)	Reference
53 (21)	221 (87)	6	7.47 (1680)	9.96 (2240)	22
51 (20)	216 (85)	6	7.94 (1785)	10.59 (2380)	16
51 (20)	221 (87)	6	6.23 (1400)	8.30 (1866)	35
48 (19)	216 (85)	6	6.54 (1470)	8.72 (1960)	32
48 (19)	221 (87)	6	5.12 (1150)	6.82 (1533)	47
53 (21)	216 (85)	4	10.95 (2461)	14.59 (3279)	Reference
53 (21)	221 (87)	4	8.59 (1930)	11.45 (2573)	22
51 (20)	216 (85)	4	9.12 (2050)	12.16 (2733)	17
51 (20)	221 (87)	4	7.14 (1605)	9.52 (2140)	35
48 (19)	216 (85)	4	7.53 (1692)	10.03 (2255)	31
48 (19)	221 (87)	4	5.89 (1324)	7.85 (1765)	46

Two other factors influencing bale tie force are compression density and restraint density. The resilient force of the cotton on the bale ties is directly related to the compression and restraint densities. The compression density is the density to which a bale is compressed (minimum platen separation) before it is released from the press. Compression density can be estimated by dividing the bale weight by the area of the press box. The restraint density is the final density of the bale after it has been removed from the press and may be determined by dividing the bale weight by the bale volume (length times width times thickness). Because calipers are required to measure the bale dimensions, it is more convenient to estimate the restraint density from the bale circumference (Anthony et al., 1980). Figure 9 demonstrates the relationship between restraint density, bale weight, and bale circumference for gin universal density bales.

The maximum tie force exerted by bales can also be reduced by uniformly distributing the lint cotton in the press box. When the lint cotton is very unevenly distributed in the press box, one tie may have over 300% more force exerted on it than another tie on the same bale. The force used to compress lint cotton and the type of bale ties used to restrain lint cotton can be varied to compensate for low moisture or large bales. Another viable method of reducing bale tie stress is to control lint moisture. Maintaining lint moisture in the range of 6% to 8% at the press can appreciably reduce the press energy consumption and bale tie forces. Increasing moisture from 5% to 8% will reduce the press force required and the press electrical energy consumption by about 25%. The bale tie force will be reduced about 20%.

There are several devices for adding moisture to the lint prior to entering the lint into the press. They range in moisture restoration capacity—some can increase lint moisture as much as 2% to 3%. The final moisture content however must not exceed 7.5% to assure qualification for the CCC Loan program. Also, biological degradation of the fiber can occur during storage when bales are warehoused at moisture levels above 7.5%. Moisture restoration is more easily accomplished when the ambient temperature is low. However, low ambient temperature increases the problem of moisture condensation on any metal that comes in contact with the moisture laden lint. To overcome this problem, all surfaces that contact the humidified lint should be heated or insulated.

Special care must be taken to ensure that the bale ties are not overstressed. Broken bale ties can be difficult to replace, since the bale must be repressed before a new tie can be applied. Bales stored with broken or missing ties are irregular in shape and subject to falling when stacked in a warehouse or holding area.

Bale ties should be of sufficient strength to restrain bales of cotton transported from the gin to the textile mill. Specifications for bale ties (wire and PET straps) are published annually by JCIBPC. Revised specifications must be consulted annually to ensure conformance with current requirements. These specifications are mandatory for entry of bales into the CCC loan program.

Bale Tie Systems. Traditionally, most bale tying at cotton gins was done manually, and hot rolled steel bands about 1 in (2.54 cm) wide were universally used. Two developments greatly influenced materials and methods used to tie out bales at the gins. First, trade regulations for upland cotton were changed from gross weight trading to net weight trading. Under the old gross weight trading system, 21 lb of tare were allowed. There were strong economic incentives to use heavy ties as well as heavy bale cover materials that together weighed about 21 lb. Therefore, heavy, hot-rolled steel bands were almost universally used. Under net weight trading, the economic incentives then called for the least expensive tie materials to be used. However, at that time most cotton bales produced in the U.S. passed through a two-stage process in which the cotton was first pressed to flat bale density (12 to 14 lb/ft^3, 192 to 224 kg/m^3) at the gins and later compressed at the warehouse to standard density (22 to 24 lb/ft^3, 352 to 384 kg/m^3) or high density (32 lb/ft^3, 513 kg/m^3) for overseas shipments. In this two-stage system, the compresses reused the six long ties from the flat bales produced at the gins. These six long ties were cut to shorter lengths when put on the smaller compressed bales, and the six leftover short pieces of wire were spliced together, providing two or three additional ties (making a total of eight or nine ties) to contain the standard or high-density bales.

The second development that influenced bale tying was the adoption of the universal density bale. Universal density bales could be produced either by the then conventional two-stage system or by a single-stage process using a universal density press at the gin. All gins in the U.S. now have universal density presses, which, unlike the presses in the two-stage system, allow for different types of tie materials to be used.

Largely because of these two developments, a variety of bale tie materials and tying systems are now in use. The two major tie materials used are polyethylene terephthalate (PET) plastic strap and high tensile steel wire with preformed loops on the ends that form a square-knot connection. A third material, galvanized wire with a twist connection, is used on a limited basis and is the third of three tie materials approved by the JCIBPC. The PET plastic strap is automatically applied although there are manual application technologies available for replacing ties that have failed for one reason or another. The preformed high tensile wire can be applied manually or semi-automatically. The galvanized wire system is fully automatic.

Fully automatic tying systems are used to apply PET and galvanized twist-lock strapping. Both employ strapping material from coils. In these systems, six or eight ties are used. Anywhere from two to eight strapping heads are normally mounted on a structure from which each strapping head applies a tie. In the cases where the heads must index to provide complete bale coverage, one head may apply anywhere from two to four individual ties. The PET systems use "friction weld" technology to fuse two ends of a PET strap thus forming the joint. Strap from coils is control fed around the perimeter of a compressed bale, cut to length, then friction welded followed by a cool-down period before the bale is released. The process takes between 10 and 15 s to complete. Thus, a bale press with a 6-tie unit and six strapping heads can tie out a bale in that same amount of time.

JCIBPC specifications state PET plastic strap is to be 0.75 in (1.9 cm) wide and 0.055 in (0.14 cm) in thickness with a minimum break strength of not less than 2,250 lb (10 kN). The minimum welded joint strength is to be not less than 1,950 lb (8.7 kN). Bales tied with PET strap must have recessed channels in both sides to protect the tie during handling of the bale after it is ejected from the press. It is advisable to employ recessing channels regardless of tie material to protect bale wrap from damage during handling. PET strapping may be used in 6- or 8-tie configurations.

The fully automatic galvanized wire twist-lock system operates in a similar fashion to the PET system. Galvanized wire is control fed from coils around the perimeter of a compressed bale, cut to length, then both ends of the cut wire are mechanically twisted together to form the joint. The entire process takes less than 10 s to complete. Bales tied with the automatic galvanized wire system also must have recessed channels in both sides to protect the tie during handling of the bale after it is ejected from the press. The automatic galvanized wire system strap material as specified by the JCIBPC is listed in the last row of Table 6.

The JCIBPC provides for five high tensile steel wire strap materials in their specifications (Table 6). High-tensile steel wire straps with preformed loops on the ends may be either hand connected or by means of semi-automatic mechanical tying machines. The simplest system is completely manual. The wire is passed around the top, bottom, and one side of the bale, and the square knot connection is manually made along the other side of the bale. This process requires a person to have considerable dexterity and strength. It was not long before semi-automatic systems were developed as work assists to replace the manual. To put less strain on the connections, the manual strap must be rotated around the bale so that the connection lies between the crown and the edge of the bale. Semi-automatic devices properly locate the knot requiring no further manipulation. Six- or eight-tie configurations may be used depending on material selection (Table 6).

One such semi-automatic system employs knotter devices in the top platen of the press. One looped end of the wire is fed into one side of the top platen and hooked in the knotter device. The free end of the wire is then fed around the bale. A 90° bend is manually

Table 6. High tensile and galvanized wire strapping specifications per JCIBPC standards[z]

Wire diameter	Material	Wire gauge	# of ties	Tensile strength	Min. breaking strength	Min. joint strength
mm (in)				MPa (Ksi)	--------------- kN (lbs) --------------	
3.76 (0.148)	HT Steel	9	8	1379 (200)	15.12 (3400)	9.34 (2100)
3.56 (0.140)	HT Steel	9½	8	1655 (240)	15.12 (3400)	10.28 (2310)
3.76 (0.148)	HT Steel	9	6	1655 (240)	15.12 (3400)	10.68 (2400)
3.94 (0.155)	HT Steel	8½	6	1517 (220)	18.68 (4200)	11.12 (2500)
4.11 (0.162)	HT Steel	8	6	1379 (200)	18.68 (4200)	11.57 (2600)
3.43 (0.135)	Galv. Steel	10	6	N/A	13.04 (2931)	11.47 (2578)

[z]Refer to latest JCIBPC specifications for current standards, https://www.cotton.org/tech/bale/specs/ties.cfm

formed about 6 to 8 in from the free end of the wire, allowing the operator to push the end horizontally into the top platen knotter device. When the end is pushed into the device, the two looped ends of the wire are brought together, making the square-knot connection. This system reduces much of the dexterity and strength required and has a further advantage in that the knot is now located on the top of the bale without having to rotate the stiff wire after making the knot, as in the purely manual system.

Another semi-automatic wire-tying system employs chutes on the side of the bale opposite where the operator or operators stand, thus allowing the wires to be inserted from one side of the bale. The chutes then return the wires back to the operators. A power assist device draws the wire up tight to make the square-knot connection.

Still another semi-automatic wire-tying system removes practically all the manual effort and has the further advantage of forming the knot on the bottom crown of the bale. It can accommodate capacities of over 60 bales/hr with only one operator. This system employs "arms" on both sides of the top platen of the press— one pair of arms for each tie. These arms are pivotally mounted to the top platen and move from an outstretched position to a down position along the sides of the bale. Near the outer ends of the arms are "wrists" that also pivot as the arms lower from their outstretched positions. Thus, the wrist movement causes the extremities of the arms to pass into slots in the bottom platen, where knotter devices are located. One operator loads the six or eight wires in the arms when the arms are in the outstretched position, forming a straight line with the slots in the top platen. This is done while the previous bale is ejecting, the bottom ram is descending, and the press boxes are rotating; thus, the loading of the wires does not interfere with the press cycle. When the next bale is fully compressed, the arms move down, forming two 90° bends in the wires on each side of the bale and pushing the loop ends of the wires together in the bottom press platen knotter device to make the square-knot connection. The arms then return to their up, or outstretched, position. The complete tying action takes less than 10 s. In all these strapping and wire-tying systems, the bales are generally strapped naked; this reduces personnel exposure to the moving parts of the baling press and strapping mechanism and increases the capacity of the baling operation with minimum labor requirements. Even so, personnel working around a baling press should be protected by face shields and switch mats, or other devices preventing hazardous machine motions when personnel might be in the area.

Analysis of Cotton Bale Tie Failures. Excessive cotton bale tie failures at gins and during shipping and warehousing place unnecessary financial strain on the cotton industry. Analysis of the cause of failures on bales from specific gins is not simple and direct because many factors affect the forces on restraining ties. For a systematic guide to determine the cause of bale tie failures, see Anthony (1982a). A copy of Anthony (1982a) can be obtained from https://www.cotton.org/tech/bale/upload/1982-Analysis-of-Cotton-Bale-Tie-Failures-A-Users-Guide.pdf.

Analyses of the potential causes of bale tie failure must account for the three main factors (platen separation, lint moisture, and bale circumference) that govern the stresses within the bale ties. A decision matrix to resolve the cause of excessive bale tie failures is given in Figure 12. The decision matrix can be used alone and requires minimal information within the decision blocks. The matrix cannot be used for isolated bale tie breakages that involve a few bales at random, but it can be used to locate causes when failures occur repeatedly. Further analysis of bale tie breakage is needed in complex cases (Anthony, 1982a).

Bale Handling Systems. Most medium and high-capacity cotton gins have power-operated bale handling systems to remove the bales from the press and convey them to their wrapping and weighing stations. From this point, the bales are often conveyed on their flat sides to a bale loading dock or adjacent warehouse, where they are down ended to stand on their heads and accumulated in a row. A clamp truck then picks up four or more bales at a time to load the bales into waiting trucks, boxcars, adjacent warehouses, or bale yards. These systems generally incorporate devices for facilitating the wrapping, weighing, and tagging of bales and for recording bale information.

A variety of conveying systems are employed from the bale wrapping and weighing station; the system used depends upon the layout of the gin plant. In the simplest systems, the wrapped, weighed, and tagged bales move on a conveyor only a few feet through the gin wall where they are down ended and moved by a pusher, sliding on their heads to form a row of bales butted together. The pusher also makes room for the next bale to be down ended from the conveyor. In other systems where the bale warehouse or loading conveyors, changing direction through bale turners and,

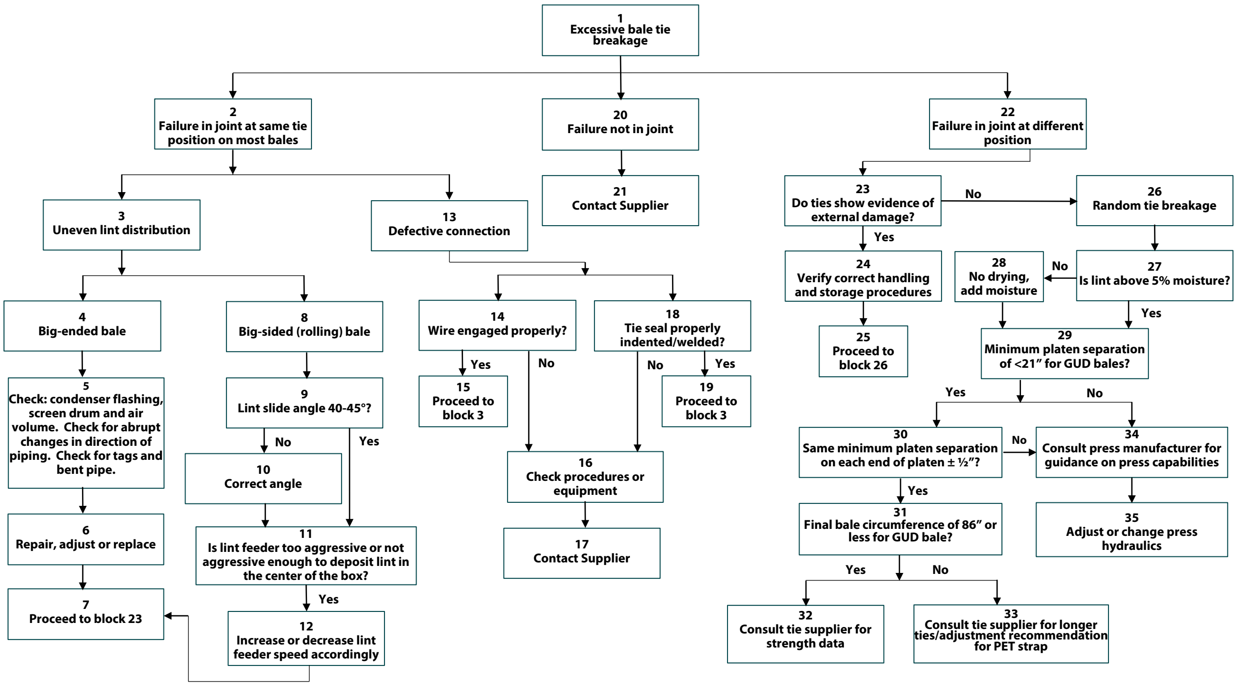

Figure 12. Decision matrix for analysis of the cause of excessive tie failures in cotton bales.

in some cases, riding over elevated conveyor systems across roadways or other obstructions to reach their final destination.

Starting at the baling press, the first part of the bale handling system automatically ejects the bale out of the press. In up-packing presses this is generally accomplished by a very simple device that tilts one or more platen bars as the following block lowers. In down-packing presses, one or more bottom-plated bars are tilted by a pneumatic or hydraulic cylinder to eject the bales from the press. These bale ejection devices are coordinated with one of two means to remove the bales from the press area and convey the bales to the bale wrapping station. With up-packing presses, in which the box is turned below floor level, a pair of conveyor chains, running from the press bale discharge point over to the bale wrapping station, is commonly used. Optionally, a bale dolly, which runs on tracks in the floor, may be used to receive the bale from the press and carry the bale to the wrapping station. Because the bales are usually ejected from an up-packing press very close to the floor level, the bale dolly will normally have a tilting top so that it receives the bales at a low level and in an inclined position. The dolly then tilts the bales up to a horizontal position as it moves toward the bale wrapping station.

On down-packing presses, either the bale dolly system or a horizontal elevated conveyor (chain, powered rollers, or belt) running from the press bale discharge point over to the bale wrapping station are used to accommodate the bale being ejected from the press at a higher level from the floor. The bale dolly may have a non-tilting top surface on which the bale can fall on its flat side. The top horizontal surface of the dolly/conveyor are at a fixed level from the floor and a proper height for receiving the bale at the press and for aligning the bale with the bale wrapping station.

To be accepted in the trade, bale wraps must completely cover the bales on all six sides. To accomplish this, a simple and efficient system, commonly called the bale stuffer system (Fig. 13), is used. This system employs two vertically hinged, funnellike panels over

Figure 13. Bale stuffer system (courtesy of Cherokee Fabrication).

which a preformed bag of wrapping material is manually placed. A bale pusher foot, mounted on a carriage that rides either above or below the bale and that is driven by a chain drive, pushes the bale off the dolly or rollers on which the bale is resting. This motion is at a right angle to the movement of the bale from the press to the entrance of the bale wrapping station. As the bale moves into the bale stuffer, the side panels hinge outward under the pressure of the bale, acting much like shoehorns by causing the bale to be inserted tightly into the preformed bag. The bale pusher continues to advance the bale until it is completely out of the bale stuffer station. At this point, the bale usually rests on a weigh scale, where the bale is weighed, and the open end of the bag is closed and secured. The bale pusher foot, which is backed away from the bale during the bag closing sequence now advances the bale onto powered conveyors that carry the bale to its down ending point, or, in the case of close-coupled installations, the bale pusher foot moves the bale directly to the down-end point. The bale tags (Delhom et al., 2020) are usually affixed to the bale wrap material at the weigh station, but, in some close-coupled installations, the bale is first down ended before the bale tag is affixed and before the open end of the cover is sealed.

Semi-automatic and automatic wrap applicators are becoming common enhancements to bale handling systems as reliable labor sources are scarce and associated costs increase with each successive year. One manufacturer offers a system which applies approved woven polypropylene bale bags mechanically and automatically takes the USDA-AMS required cotton sample coupons for classification (Delhom et al., 2020) as part of the process. Nylon staples are automatically applied to close the bag prior to ejection from the bagger. Another manufacturer utilizes approved polyethylene bale wrap material from a continuous roll that is wrapped around the bale, cut, and then heat-sealed before ejection from the unit, all automatically. Prior to wrapping, bale samples are pulled and collected automatically. Once wrapped, a permanent bale identification tag is applied automatically. These systems can reduce labor requirements at the bale press by as many as four people.

A variety of bale covering materials are approved by the JCIBPC and CCC. The material must protect the bale from contamination from outside sources by resisting abrasion and tearing. The bale cover material must also not cause contamination of the cotton; fibers or strips of the cover must not adhere to the bale surface. The cover material must be porous enough to allow water to seep out in case the bale is exposed to rain. Furthermore, the porosity of the material should be such that the cotton within will come to equilibrium relatively quickly with atmospheric moisture conditions.

Bale samples must be drawn in such a way that the bale cover material does not leave exposed cotton areas. A simple and efficient system for drawing bale samples uses devices in the top and bottom platens of the press, commonly called cookie cutters. These are simply plates of steel approximately 0.25 in (0.6 cm) thick and about 6 by 12 in (15 by 30.5 cm) with flanges turned up on three sides about 1 in (2.5 cm) high. The edges of these flanges are sharpened so that when the bale is pressed the compression force cuts neat plugs of cotton. These plugs are temporarily held in place by the one uncut side so that the press operators can easily reach over and tear the samples from the sides of the bale. It is extremely important that these operators wear protective face and arm shields. Bales fresh from the baling press are most likely to have their ties break. When ties break, they can whip out with considerable force and cause severe injury to personnel who are not wearing protective shields. As mentioned previously, the automatic and semi-automatic wrapping systems include methods for collecting samples automatically.

These bale handling systems in which the bale cover is affixed outside the press and the bale is weighed and conveyed with the use of automated mechanisms as described above are a major contributing factor to high-capacity ginning with reduced labor and reduced hazard to personnel.

Bale Covering. Bales should be fully covered, and all bale covering material should be clean, in sound condition, and of sufficient strength to adequately protect the cotton. The material must not have salt or other corrosive material added and must not contain sisal or other hard fiber or any other material that will contaminate or adversely affect cotton. Approved bale coverings are published annually by the JCIBPC (National Cotton Council, 2023) and should be consulted for current guidance.

Since the adoption of net weight trading the weight of bale packaging materials has declined. The tare weights shown in Table 7 are established for all bales in the U.S. meeting the specifications for acceptance in the CCC loan program and as specified by the JCIBPC (National Cotton Council, 2023).

The JCIBPC strongly encourages software vendors to accommodate fields for bagging and tie types in their software package updates. Gins are now

Table 7. Official tare weights for approved and experimental materials, 2022-2023 Marketing Year[z]

Wrapping materials	Bale ties[y]		
	PET Plastic Strap[x]	All 6 wire	All 8 wire
	------------------------------ kg (lbs) ----------------------------		
Polypropylene (woven) [approved or experimental][w], Polyethylene (woven)[v]	0.91 (2)	1.81 (4)	2.27 (5)
Polyethylene (PE) film bagging[u]	1.36 (3)	1.81 (4)	2.27 (5)
Lightweight woven cotton bagging [experimental, West Region/Export Only][t]	1.36 (3)	1.81 (4)	2.27 (5)
Cotton bagging [fully approved][s]	1.81 (4)	2.72 (6)	3.18 (7)
Fully restrained PET bagging (GinFast^{TM})[r]	1.36 (3)	(does not utilize traditional ties)	

[z]Refer to latest JCIBPC specifications for current standards https://www.cotton.org/tech/bale/specs/ties.cfm

[y]Wire or strapping must meet all applicable requirements in JCIBPC specifications Sections 1.1. Wire ties must meet all requirements in Section 1.2.1. PET plastic strapping can be identified by its translucent or opaque green color. Such approved PET plastic materials must also meet all requirements in Section 1.2.2.

[x]Includes both approved PET plastic strap and PET plastic strap in compatibility test programs.

[w]Woven polypropylene can be identified by its translucent white, translucent light gold color or translucent light blue color. This category includes all patterns of polypropylene including bag and sheet combinations and spiral sewn bags. Such approved material must meet all other requirements in JCIBPC Specification Section 2.2.3.

[v]Woven polyethylene can be identified by its translucent natural color. Such approved material must meet all other requirements in JCIBPC Specification Section 2.2.4.

[u]Linear low-density or tri-extruded polyethylene film bags can be identified by their clear, light brown, light blue, or yellow tint and the words "100% linear low-density polyethylene" or "100% LLDPE" or "tri-extruded" printed on each bag. Such material must meet all other applicable requirements in JCIBPC Specification Section 2.2.2.

[t]Lightweight woven cotton bagging in an approved experimental test program.

[s]Cotton bagging is any other knitted or woven cotton package material made from all cotton fibers. Cotton bagging must meet all other requirements for that type of bagging set forth in JCIBPC Specification Section 2.2.1.

[r]The tare weight for Fully Restrained PET Bagging was raised from 2 to 3 lb. in 2016. This was because the PET tape denier increased from 3200 to 3600 and the construction was modified from 8 x 8 to 10 x 8 (PET tapes per square inch).

required to include bag and tie codes when they send bale data to warehouses. Warehouses are required to include bag and tie codes on all warehouse receipts. Table 8 includes required bag and tie codes for all approved and experimental materials (National Cotton Council, 2023).

Moisture Change in Cotton Bales. Cotton is usually dried, cleaned, ginned, and packaged at a moisture content well below its eventual equilibrium moisture content in storage. The moisture content and other physical responses of cotton to environmental conditions vary depending primarily upon the surrounding atmosphere (Hearle and Peters, 1960; Griffin, 1974).

When the humidity of the storage environment is higher than the humidity within the bale, the bale will gain moisture until it equilibrates with the environment. As the bale gains or loses moisture during storage, the weight of the bale changes. The rate of moisture gain is significantly influenced by the density of the cotton bale and the type of bale covering (Anthony, 1982b). The rate of moisture gain is also influenced by the type of bale covering. The rates of moisture gain for bales covered with polypropylene, burlap, and extrusion-coated polypropylene are similar. Figure 14 depicts the change in bale weight over time for bales covered with woven polypropylene or polyethylene and ginned at 4.5% moisture. Bales of cotton ginned at less than 5% lint moisture, covered with polypropylene, and stored for over 60 days at high humidities (75% to 80%) will absorb about 10 to 15 lb (4.5 to 6.8 kg) of water, which will increase the lint moisture by up to 7% or 8%.

Bale Press Maintenance. Uneven formation of the lint batt in the condenser is the primary cause of "big-ended" bales (Anthony, 1982a). Big-ended bales (Fig. 15) are formed when more lint is deposited at one end of the press box than at the other. During the pressing operation, the increased resistance from the lint at one end of the press box forces the hydraulic compression cylinder(s) to lean towards the end with the most lint forcing the follow block into an inclined position, thus forming a wedge-shaped bale. Uneven stress on bale ties and stacked bales falling in the warehouse are just two of the issues caused by big-ended bales.

Table 8. Required bag and tie codes for all approved and experimental materialsz.

Type of bagging	Position 36	Type of strap/tie	Position 37
Cotton, [Fully approved]	C	PET (Polyester) – 6 strap	1
Polyethylene (Film)	P	Steel – 6 wire	2
Polypropylene (Woven)	W		
Lightweight cotton, [West Region/Expert Only]	L	Steel – 8 wire	4
Experimental	X	Experimental	0 (zero)

[z]Two single character fields for bagging and tie codes are available in the Electronic Warehouse Receipts manual. The manual identifies field ten as "Bagging Type" and the field occupies position 36 on the electronic warehouse receipt. The manual identifies field eleven as "Ties" and the field occupies position 37 on the electronic warehouse receipt.

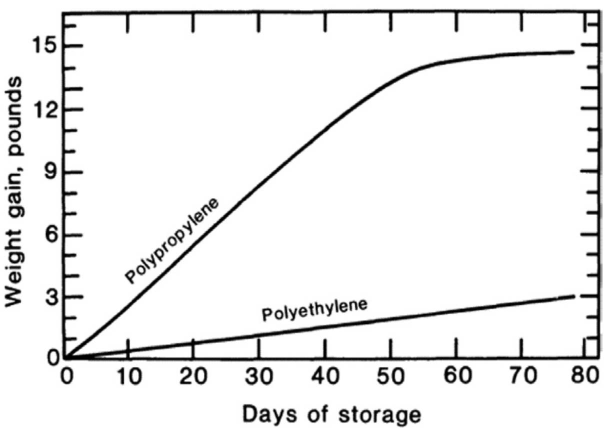

Figure 14. Weight gain of 500-lb universal density cotton bales covered in woven polypropylene or polyethylene and stored at 75° F and 75% relative humidity. Initial moisture content of the bales was 4.5%, wet basis.

Figure 15. Big-ended bale .

Fixed-length ties help mitigate the effect of an uneven shape when the bale is released from the press, but do not remove it entirely. Uneven lint distribution can be identified from observing the size of the connection on wire ties, the more cotton under the tie, the more force on the tie, and the smaller the "knot" (Anthony, 1975). In the case of plastic ties, the denser regions of the bale and subsequent higher resilient force tend to stretch the plastic and its welded joint more so than those in less dense regions. Sometimes condensers will produce batts that are heavier in the center. This will not only put excessive stress on the center ties, but also can result in wedge-shaped bales from top to bottom because the low-density cotton at the ends of the bales opposite the compression platen tends to flow laterally when released from the press box.

Rolling bales (Fig. 16) are caused primarily by poor distribution of the lint from front to back in the charging box under the tramper as the tramper makes each downward stroke. One visual indication of poor distribution is an exaggerated gap between the bale tie(s) and bale on one side of the bale. This can be caused by faulty action of the charging device (Watson

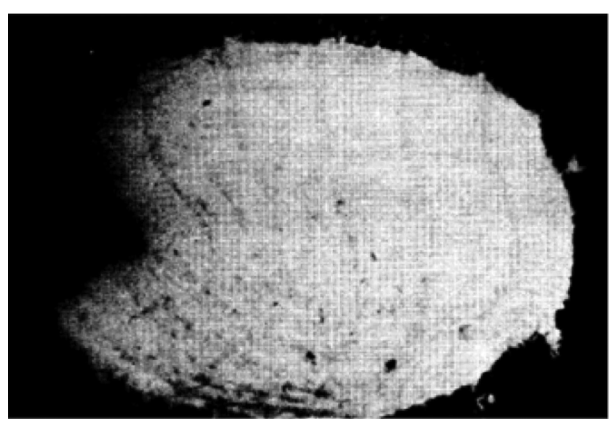

Figure 16. Rolling bale. Source: USDA-ARS Agricultural Handbook 503, "Cotton Ginner's Handbook," U.S. Government Printing Office, 1977, pg. 45.

and Stedronsky, 1943) or an inadequate supply of lint to the press for an extended period. Another cause of rolling bales is faulty action of the press "dogs" on one side of the press box (Fig. 17). If the dogs do not

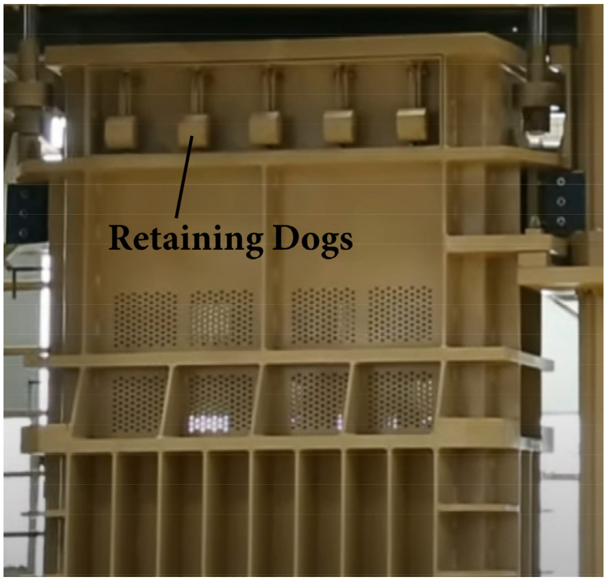

Figure 17. Typical press dog arrangement on press box (courtesy of Bajajconeagle LLC).

reliably hold down the lint uniformly on both sides of the box, the lint density from the front to the back of the box will be distributed unevenly and a rolling bale may be produced. Managing the amount of material fed per stroke of the tramper and application of a follow block guide system help limit the development of rolling bales. Rolling bales, like big-ended bales, cause stacking issues in the warehouse which is a serious safety concern. Rolling bales can also be a safety issue at the gin. On rare occasions an unrestrained rolling bale has ejected out of a press box during compression. This may cause injury or death to personnel and damage to equipment.

The danger of tramper breakage, damage to ram seals, and press distortion is increased with uneven bales. During bale compression, the leaning of the main hydraulic compression cylinder(s) towards the heavier end or side creates extreme side forces that may result in damage to the hydraulic cylinder and/or press structure. It is not an uncommon occurrence for the main bottom press sill to shift as the result of a big-ended bale. Often this will cause the center column to lean and press boxes to tilt, one end up, the other down. The end that is up may then contact the bottom of the press deck, keeping the boxes from turning. Should such an event occur, the press sill should be moved back in place and the cause determined before putting the press back in operation. Otherwise, the condition may once again present itself. Limiting the movement of the press sill is not recommended. Should the sill not be allowed to move, the energy causing the displacement will be distributed somewhere else in the structure leading to potentially extensive damage to the structure or major components such as the main compression cylinder bushings and packing glands.

Stress and fatigue take a toll on press structures. The nature of press operation is such that cyclical stresses are imparted to key structural members, typically starting with zero stress under static conditions, quickly accelerating to a condition of high stress, then reversing back to zero stress, a repeated cycle for each bale of cotton compressed. The constant stress reversing results in "fatigue", a lifetime-limiting and predictable phenomenon typical of stress reversing operations. Fatigue begins with the very first press cycle and continues to propagate throughout the life of the bale press. Design for fatigue was not foremost in the minds of press designers during the years when high-capacity gin plants processed twenty thousand bales or less per season. With current ultra-high-capacity gin plants producing one to two hundred thousand bales per season, presses are experiencing "twenty years'" worth of fatigue in the span of just a few years. A way to visualize the long-term effect of fatigue from stress reversal on a bale press is by studying a SN chart. Figure 18 is a typical SN chart representation of low-carbon steel (ASTM A36 / A36M – 19) used in construction of cotton gin press components such as press boxes and sills. Note the inverse relationship between the number of stress reversals and amount of stress (psi) required before failure. Availability of such data allows the designer to estimate a predictable life expectancy for the design and make informed decisions based on the estimate.

No. of stress reversals (N)	Cyclic stress (Sr) for failure psi
1000	81000
2000	75465
4000	70307
8000	65501
16000	61024
32000	56853
64000	52967
96000	50818
144000	48757
216000	46779
324000	44881
486000	43060
729000	41313
1000000	40000

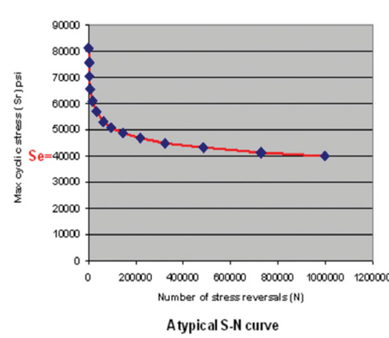

Figure 18. Typical SN curve illustrating fatigue due to cyclic stress loading.

SAFETY TIPS FOR PACKAGING COTTON

1. Avoid contact with gin machinery.
2. Become familiar with warning devices (horns, buzzers, etc.) before working on any part of the gin. Ask your supervisor if you have any questions about what each warning device means or how it is used. Obey all warning signs.
3. Prior to startup, make certain that all personnel are clear of the machinery. Sound the warning device 10 s for other workers to get clear of machinery before starting the press.
4. Before you inspect, clean, adjust, or maintain any gin machinery, cut off and lock out all power at the master disconnect switch. Put your personal lock on each switch box and put the keys in your pocket. After lockout, do not reach inside.
5. Be sure that the interlocks on the tramper doors are operational. Never put any part of your body inside the press box or lint slide unless the master disconnect switch is locked out.
6. Do not place any part of your body beneath the follow-block while the ram is in motion.
7. Do not enter a press pit or any platform on the press while the power is on. Where possible, the same holds true for any platform on the press.
8. Stand back from the rotating press circle and the doors that automatically open.
9. Stay at least 5 ft from bales as the ram is released because ties may break.
10. Stand clear as bales are ejected and conveyed through the gin.
11. If you are manually strapping a bale or working close to a bale, wear protective clothing, face protection, and gloves.
12. When automatic strapping heads are in use, do not place any part of your body between the heads and the end or center columns of the press.
13. Never attempt to make hydraulic system repairs with a bale in the press or with the ram in any position other than completely retracted. Hold the follow-blocks in position with blocks or straps.
14. Bleed off pressure and then use extreme caution when disconnecting flexible hoses or other hydraulic fittings. Do not alter settings on relief valves or pressure switches. Use only recommended oils and fluids in hydraulic systems. Do not use highly volatile fluids for cleaning.
15. Be aware that many presses are automated and can start into motion at any time without warning, be alert. Electrical controls are not perfect!
16. Remember that as much as 1 mil lb of force may be required to compress a bale of cotton. Forces in bale ties may exceed 2,000 lb (8,900 N). Be aware of the dangers associated with the forces involved in bale packaging operations.

SUMMARY

Bale packaging protects the quality of the ginned lint. Smooth operation of the ginning plant relies on a properly sized and well-maintained bale press and associated systems. Proper maintenance of the bale packaging systems results in properly shaped bales which can be transported and stored efficiently and safely. The safe operation and proper maintenance of the bale packaging systems is essential for the proper operation of the ginning plant.

Although bale presses may be designed to produce Universal Density or High Density bales, only Universal Density bales are approved by USDA for use in the U.S. All bale coverings, strapping or ties must be approved by the USDA and the JCIBPC.

DISCLAIMER

Mention of trade names or commercial products in this publication is solely for the purpose of providing specific information and does not imply recommendation or endorsement by the USDA, an equal opportunity employer.

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