Analysis of Cotton Bale Tie Failures: A User's Guide

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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 in the restraining ties. Previous research (1, 2, 3 and 4) has shown that bale tie forces are primarily a function of three factors:

1) Compression density
2) Restraint density
3) Lint moisture content

This report presents a systematic approach to isolating the sources of tie breakage and suggests solutions to the problem.

The maximum compression density in ginning terms is the bale weight divided by the bale volume in the press at the minimum platen separation. Since the press box size is constant for a given press, the maximum compression density can be estimated from the bale weight divided by the area of the press box and the platen separation.

The restraint density is the final density of the bale after it is 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 (5). Figures 1 and 2 demonstrate the relationship between restraint density, bale weight and bale circumference for gin universal density (GUD) and gin standard density (GSD) bales that are 20 and 21 inches wide, respectively.

The force required to compress lint cotton varies greatly due to variations in lint density and lint moisture content (Figure 3). The resilient force exerted on bale ties can be estimated from the platen separation, lint moisture content, and bale circumference (Figure 4). Small changes in platen separation and bale circumference dramatically affect the force exerted on the bale ties (Figure 5). Table 1 indicates that a 2-inch decrease in platen separation decreases the bale tie forces by more than 30 percent whereas a 2-inch increase in bale tie length decreases the bale tie forces more than 20 percent. Bale tie forces increase about 15 percent as the lint moisture content decreases from six percent to four percent (wet basis).

Approach

The systematic analysis of the potential causes of bale tie failure can be divided into the same three areas that govern the stresses within the bale ties. In addition, consideration must be given to the distribution of lint within the bale. A decision matrix to resolve excessive bale tie failures is given in Figure 6. The decision matrix can be used "stand alone" since minimal information is provided within the decision blocks. The remainder of this report provides further explanation of the analysis of bale tie breakage and may be needed in complex cases. The matrix cannot be used for isolated bale tie breakages that involve a few bales at random, but its use will be invaluable to locate causes when failures occur in the restraining ties of numerous bales.

The flow-chart type decision matrix in Figure 6 is keyed to an index number that is positioned outside the upper left hand corner of each box. To use the matrix, enter block one entitled "Excessive bale tie breakage" and follow the directional arrows until the cause of the failures is isolated. At that point, three possible courses of action are possible:

1) Take corrective measures as indicated.
2) Contact supplier of bale ties.
3) Consult press manufacturer.

Each numbered decision block will be explained in the similarily numbered paragraphs that follow:

1. *Excessive bale tie breakage.* Entry point of matrix.

2. *Failure in joint at same tie position on most bales:* This block identifies the problem as one that occurs in a fixed pattern.

3. *Uneven lint distribution:* Research (6) has shown that the distribution of lint in the press box, laterally and longitudially, can substantially increase the force on certain ties.

4. *Big-ended bale:* These bales are usually caused by problems with lint flues or condensers.

5. *Check condenser flashing,...:* Lint cotton is conveyed from the gin stands or lint cleaners to the condenser above the lint slide by a continous flow of air. Any deviation from uniform flow will cause a nonuniform lint distribution. Bent or battered lint flues, tags, rivet heads, or protrusions inside the flue, or abrupt changes in the direction of the flow of lint immediately before it reaches the condenser can result in an uneven distribution of lint on the screen of the condenser drum. This uneven lint distribution will be evident in the packaged bale.

Sheet metal deflectors are sometimes used in lint flues to enhance the uniformity of the lint distribution.

Condensers in poor operating condition, flashings in bad condition, and nonuniform drum resistance may cause more lint and air to be directed to one end of the condenser drum than to the other. As a result, the lint will be distributed unevenly after it leaves the condenser, possibly producing a big-ended bale.

Battery condensers that discharge the conveying air from only one side are critical to air volume. Excess air will cause the batt of lint to form on the side 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 is sometimes necessary. Work at the Cotton Ginning Laboratory, Stoneville, Mississippi, has shown that a condenser that discharges the conveying air from both sides (double manifold) can be adjusted to produce a very uniform batt.

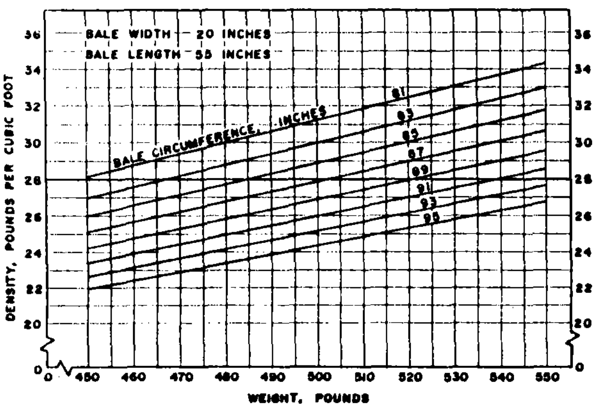

Figure 1. Relationship of density, net weight, and bale circumference for gin-universal-density bales 20 inches wide and 55 inches long.

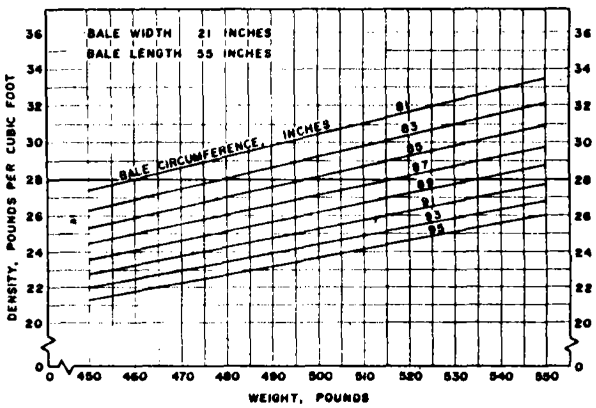

Figure 2. Relationship of density, net weight, and bale circumference for gin-universal-density bales 21 inches wide and 55 inches long.

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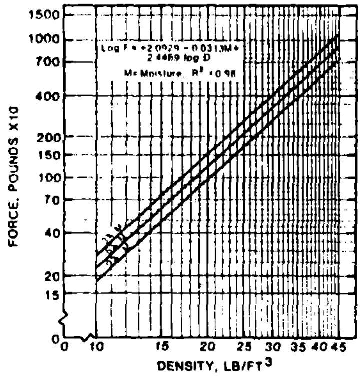

Figure 3. Predicted force to compress lint cotton in a gin universal density or gin standard density bale press to given densities at three moisture contents.

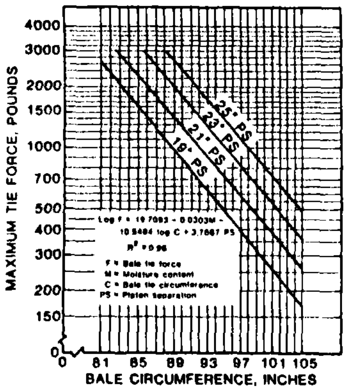

Figure 4. Maximum tie force per tie exerted by 500-pound, gin standard or gin universal density bales of Upland cotton at five percent lint moisture content (based on 15 percent of the total bale tie force per tie).

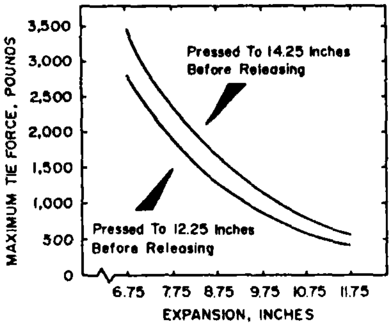

Figure 5. Effect of bale expansion on the maximum force on one tie of a compress universal density bale (with three percent moisture) 20 minutes after release of platen pressure.

6. *Repair/adjust:* If problems are noted in block five, they should be resolved before proceeding.

7. *Proceed to block 23:* After the problems are resolved, additional checks should be made by advancing to block 23.

8. *Big-sided bale:* These bales may have more cotton in the front or rear section of the bale.

9. *Check lint slide angle...:* Lint cotton is carried from the condenser to the lint feeder by a sheet-metal trough called a lint slide. The lint slide is normally installed on a 40- to 45-degree angle. A larger or smaller angle may cause the lint to be deposited in the front or rear of the press box rather than distributing it evenly.

10. *Change angle:* If the angle is not between 40 and 45 degrees then it must be changed.

11. *Is lint/feeder too aggressive...:* The lint feeder is used for moving lint from the lint slide into the charging box of the press. There are four basic types of feeders: (1) the revolying paddle kicker, (2) the belt feet used with the kicker, (3) the lint pusher, and (4) the air suction feed.

The lint feeder is intended to deposit lint into the charging box with a fast but gentle action, without agitating, turning, rolling, tumbling, tearing, or otherwise breaking up the batt as it is received from the condenser. The speed or rate of sweep of the lint feeder determines whether the lint will be deposited in the front, middle, or rear of the charging box. If the discharge is too strong, more lint will be deposited in the front of the charging box than in the rear. The opposite effect will be observed if the discharge is too weak.

12. *Change speed if necessary:* If the lint feeder is too fast or too slow, the speed must be adjusted before advancing to the next step.

13. *Defective connection:* Two types of connections are used—one for wire and one for flat strapping. Identify the type in use and proceed.

14. *Wire engaged properly:* The wire connection (knot) can be improperly engaged by inexperienced personnel. In such instances, the failed loop in one end of the wire will be nearly straight.

15. *Proceed to Block three:* If the wire was properly joined, a problem exists with the lint distribution within the bale. Proceed to Block three.

16. *Check procedure or equipment:* Instruct personnel in the correct method of making the wire connection, or adjust automatic-strapping device to indent or crimp seals properly.

17. *Contact supplier:* After all available expertise has been exhausted, then contact the supplier of the tie or equipment for assistance in solving the problem.

18. *Seal indented properly?:* Inspect the seal and strap to ensure that seal indentions do not significantly cut into the strap and that the seal indentions are sufficiently deep to allow the seal to make strong connection. A new crimped joint does not cut into the strap. Inspection of the seal may require guidance from the manufacturer.

19. *Proceed to Block three:* Since the seal was properly indented or crimped, a problem must exist with the lint distribution within the bale. Proceed to Block three.

20. *Failure not in joint:* For most wire and strapping, the joint is the weakest point. If the failure occurs in the straight length of the tie, then the supplier should be contacted.

21. *Contact supplier:* The supplier can provide strength data for the ties.

22. *Failure in joint at different tie position:* Failures at different tie positions on different bales suggests that the lint is evenly distributed.

23. *Examine failed ties for external damage:* Handling equipment such as lift trucks may damage ties after they are installed on the bale. External nicks that weaken the tie can occur before or after they are placed on the bale.

24. *Review bale handling procedures and correct:* When external damage is ascertained it can usually be traced to the source by following a bale through its handling procedure.

25. *Proceed to Block 26:* After poor handling procedures are corrected, the cause of the failures should be further investigated since failures may be the result of multiple causes.

26. *Random tie breakage:* No consistent pattern exists as to which of the bale ties is broken.

27. *Lint moisture above five percent?:* Lint moisture samples should be taken at the gin to ensure that the lint is above five percent moisture content (wet basis).

28. *No drying, add moisture:* If the moisture content is below five percent, moisture should be added to the cotton before the gin stand or before the bale press. A reduction in moisture of two percentage points increases the forces exerted on the bale ties by about 15 percent.

29. *Minimum platen separation...:* Based on 1982 specifications for bale packaging materials (7) and on bale tie force equations developed at the U.S. Cotton Ginning Laboratory, the following guidelines for minimum platen separations are suggested for bale presses:

20" or less for GUD bales
26" or less for GSD bales
13" or less for CUD bales

These guidelines are intended as points of reference rather than standards. Minimum platen separations should be equal to or smaller than the reference points. As mentioned previously, a two-inch decrease in platen separation decreases *the bale tie force* by over 30 percent. Note, however, that about 30 percent more force is required to *compress* the bale an additional two inches (Figure 3).

30. *Same minimum platen separation...:* After considerable usage bale presses may become somewhat misaligned. Compress a bale of cotton and measure the platen separation on each end and in the middle of the platen. If the variation is greater than one-half inch, then it must be corrected.

31. *Final bale circumference...:* Based on the 1982 specifications for bale packaging materials and on bale tie force equations developed at the U.S. Cotton Ginning Laboratory, the following guidelines are suggested for bale circumference:

85" or less for GUD bales
95" or less for GSD bales
82" or less for CUD bales

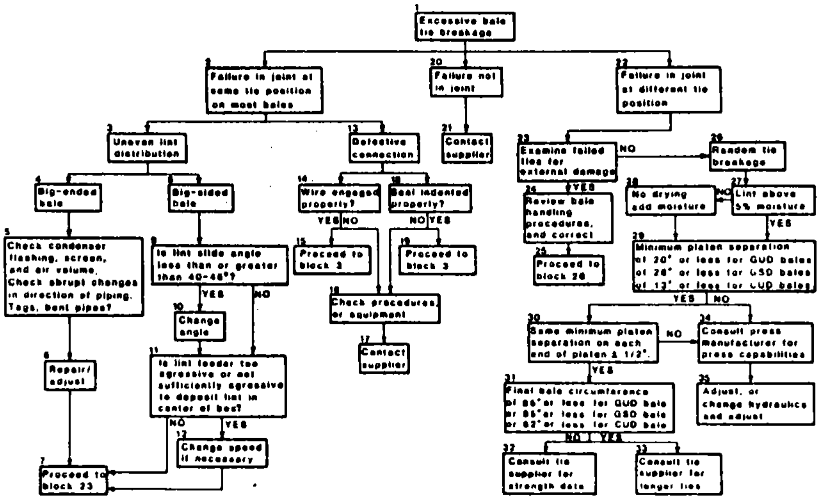

Figure 6. Decision matrix for the analysis of excessive tie failures in cotton bales.

These guidelines are intended as points of reference rather than standards. Caution must be exercised to ensure that packaged bales meet the required density standard (28 lb/ft³).

32. *Consult the supplier for strength data:* At this point all possible sources of breakage problems other than the tie should have been investigated.

33. *Consult tie supplier for longer ties:* If the current ties are shorter than those identified in block 31, a slightly longer tie would reduce the force exerted on the tie. A two-inch increase in tie length reduces the bale tie force about 20 percent.

34. *Consult press manufacturer for press capabilities:* The press manufacturer can suggest methods to realign the press and advise on the hydraulic capabilities of the press.

35. *Adjust, or change hydraulics and adjust:* Ths should be accomplished by the press manufacturer or with his guidance.

Summary

Analysis of the causes of excessive bale tie failures was simplified by development of a decision matrix that allows the user to systematically eliminate possible causes of tie failures. The matrix is sufficiently complete for use as a stand-alone aid, or it may be used in conjunction with the entire report. The report graphically documents the forces involved in packaging cotton and provides the information necessary to support the strength requirements for bales ties.

Table 1. Changes in bale tie forces as platen separation, bale circumference and lint moisture changes.

Platen separation, inches	Bale circumference, inches	Moisture content, %	Estimated force, lb[1]	Force decrease, %[2]
21	85	6	2150[3]	0
21	87	6	1680	22
20	85	6	1785	16
20	87	6	1400	35
19	85	6	1470	32
19	87	6	1150	47
21	85	4	2460[4]	0
21	87	4	1930	22
20	85	4	2050	17
20	87	4	1605	35
19	85	4	1692	31
19	87	4	1324	46

[1] Based on 15 percent of the total force exerted on all 8 ties.

[2] Bale tie forces were about 15 percent less at six six percent lint moisture than they were at four percent lint moisture.

[3] Used as basis for calculating the force reductions at the six percent moisture level.

[4] Used as basis for calculating the force reductions at the four percent moisture level.

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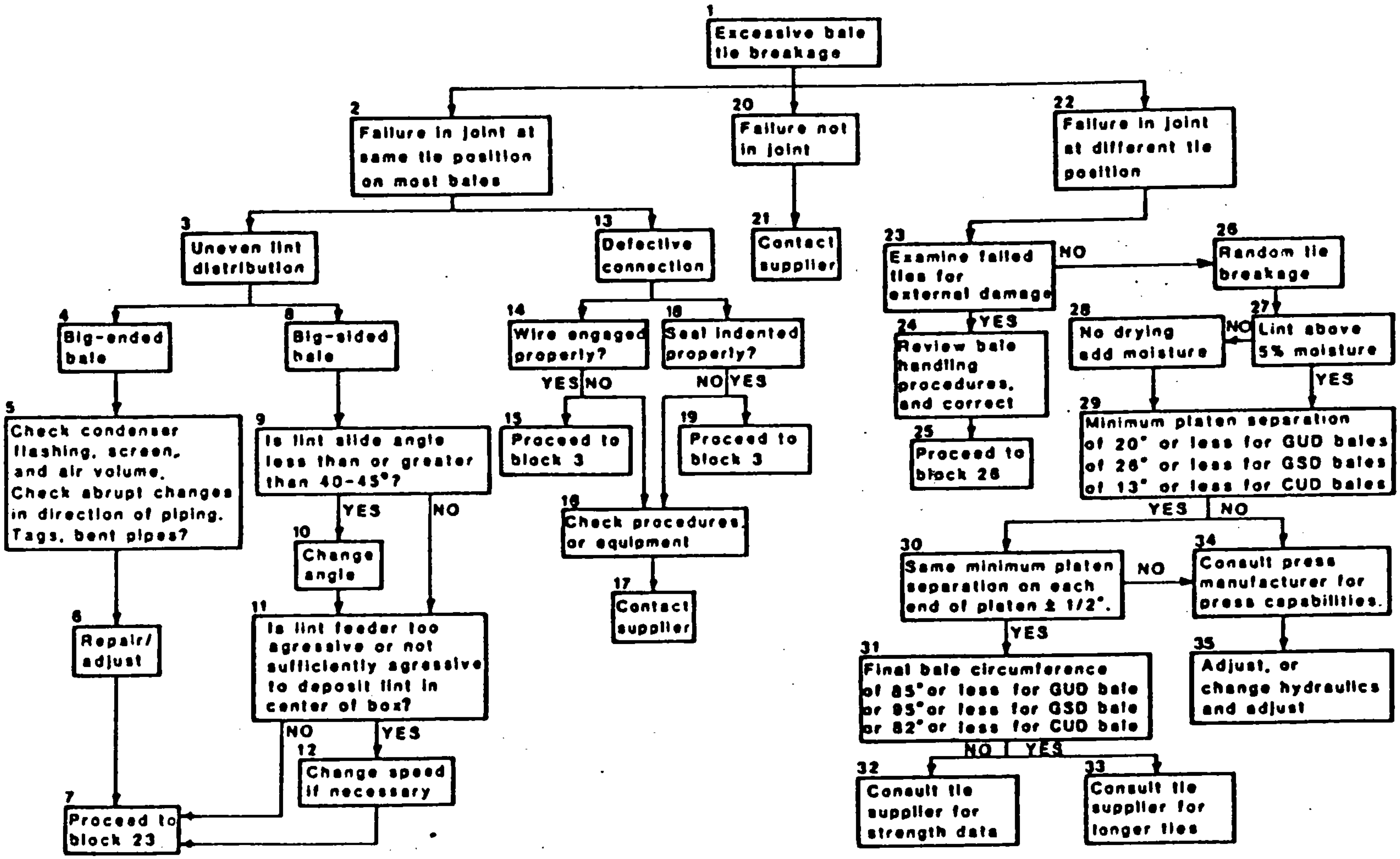

Figure 6. Decision matrix for the analysis of excessive tie failures in cotton bales.