**EVALUATION OF FIBER FINISHES FOR BLEACHED COTTON**

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## Abstract

The bleaching process removes the natural fiber lubricants – oils and waxes – from cotton fibers. To facilitate efficient processing, a fiber lubricant is needed. The sled test, as a means of measuring fiber-to-fiber friction, will be discussed. How the sled test results relate to the cardability of fiber finished with various lubricants will be shown. How the fiber finish affects the resistance of the fiber batt to needlepunching and how the sled test results correlate with the needled resistance will be shown.

## Purpose

- Determine how sled test results for fiber lubricity are related to carding experiences.
- Determine which fiber finishes provide for efficient carding.

## Background

Finishes used on bleached cotton to produce nonwoven roll goods must provide for good cardability. The fiber finish must supply both fiber lubricity and antistatic properties. Either property without the other results in poor and/or slow carding. Past work indicates that sodium acetate applied to bleached cotton provides very good static dissipation. To eliminate any static problems during these carding tests, one-percent sodium acetate will be added along with lubricating finishes. This will allow for the investigation of finish lubricity only. There are two finish categories applied to bleached cotton. One is for fiber used in medical and hygienic products. This finish must be non-toxic and maintain absorbency. For fiber that must meet Pharmacopoeia specifications, the finish must be effective at low levels. The other finish category is for fiber that will go into applications such as mattress pads, blankets, etc., where absorbency and toxicity are less of a problem. A number of finishes have already been tested for cardability, and the top finishes from previous investigations were chosen for this test.

A. Absorbent, Non-Toxic Finishes (all with 1% sodium acetate)
1. Butoxyethyl Stearate (BES) – 2 levels – Stepan Company, Northfield, IL
2. Standard Soap – Barnhardt Manufacturing Co., Charlotte, NC
3. Armak 1336 – Akzo Chemical Inc., Chicago, IL

B. Non-Absorbent Finishes (all with 1% sodium acetate)
3. Sonostat 668 – Henkel Corp., Textile Chemicals, Charlotte, NC
2. Sebosan AS – Stockhausen Inc., Greensboro, NC
3. Sebosan AS/Praelanol OK Combination – Stockhausen Inc., Greensboro, NC
4. Low Scour Fiber (natural oils and waxes remain on the fiber after processing) – Barnhardt Manufacturing Co., Charlotte, NC

C. Also included are the following fiber samples as controls:
1. No finish or sodium acetate
2. No finish with 1% sodium acetate
3. Low scour, no sodium acetate
4. Greige (unbleached)

## Procedure

1. A kier load of fiber was bleached without applying any finish, which was used for all finish applications except for the two low scoured fiber samples.
2. The fiber was finished at Littlewood Company in 75-pound lots using dye kiers.
3. The finishes applied are listed below.

| Lot No. | Finish |
|---|---|
| 1 | 1% Sodium Acetate |
| 2 | 0.5% Armak 1336<br>1% Sodium Acetate |
| 3 | 1% BES<br>1% Sodium Acetate |
| 4 | Low Scour<br>1% Sodium Acetate |
| 5 | 9.1% Sonostat 668<br>1% Sodium Acetate |
| 6 | 0.25% BES<br>1% Sodium Acetate |
| 7 | 0.8% Standard Soap<br>1% Sodium Acetate |
| 8 | 1.7% Sebosan AS<br>1% Sodium Acetate |
| 9 | 1.7% Sebosan AS<br>0.5% Praelanol OK |
| 10 | None (Control) |
| 11 | Low Scour (Control) |
| 12 | Greige (Control) |

4. Using the sled test, the fiber lubricity of each of the lots was tested by Cotton Incorporated and the University of Tennessee.
5. The finished fiber was shipped to the USDA in Clemson for carding.
6. Each lot of fiber was processed through a production size opening line and a variable speed, 40 inches wide, card equipped with revolving flats (see figure 1). Between each lot, bleached fiber without finish was processed through the entire line to remove any finish build up that may have occurred on any of the equipment or wire. The card production rate was started at 30 pounds/hour and was increased in increments up to 75 pounds/hour (maximum). The production speed

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at which card loading or other problems occurred was recorded. The processing conditions were 75°F and 58% relative humidity.

7. Samples were taken from each finish lot representing:

    a. Initial (input) fiber from Littlewood (B)
    b. Card feed mat (after opening equipment) (FM)
    c. After carding (30 lbs/hr.
    d. After carding (75 lbs/hr.) – if fiber was able to process at this rate.

    These samples were tested using HVI and AFIS instruments.

8. Sled test results were compared with actual cardability of each lot.

**Fiber Finishing Procedure (Littlewood)**

1. Fiber was packed into the kier.
2. The finish liquor was pumped through the fiber for 20 minutes.
3. The kier was drained and the fiber removed.
4. Fiber was centrifuged to remove as much excess liquor as possible, 40% wet pickup after centrifuging.
5. Fiber was then dried.

**Discussion of Carding Results**

During carding, the static at the exit end of the card was measured using a hand-held static meter. There was little or no measurable static on any of the lots containing the antistatic agent (sodium acetate) even at the highest production rates. The two lots of bleached fiber without sodium acetate had very high measurable static, and the web could not be removed from the card. This indicates that the sodium acetate eliminated static problems and any problems experienced during carding were due to the fiber lubricants.

Our past experience with the sled test has indicated that lower fiber friction values (grams-force), as measured by the sled test, yield better cardability. (Raw cotton has a value of 800-900 and bleached cotton without finish has a value of 2000-2100.)

The results in Table A show the fiber friction values, as measured by the sled test, and the carding results for all twelve fiber lots. As expected, the fiber with no fiber lubricant (finish) had the highest friction values (lots 1 and 10) and carded very poorly. The raw (greige) cotton had the lowest friction value (lot 12) and carded without any problems. Using the sled test friction values, we would have predicted that all the other lots would exhibit good cardability (lot 11 would have been marginal). However, lots 2, 5, and 7 carded very poorly, even though they had friction values in the same range as some of the finishes that carded well. This is puzzling because we have seen both soap and Sonostat 668 finished fiber card well in the past. The only difference being that sodium acetate was included in the soap finish for the first time. The soap finish relies on a balance of soap (sodium oleate) and oleic acid. The soap finished fiber was analyzed using the FTIR which confirmed that both sodium oleate and oleic acid were both present on the fiber. This seems to indicate that the cardability of bleach fiber is related to more than fiber lubricity, as measured by the sled test, and its ability to dissipate a static change.

The two low scour samples (lots 4 and 10) were from the same bale of fiber. The low scour is accomplished by using a low concentration of sodium hydroxide, which leaves some of the natural oils and waxes on the fiber. Lot 10, which had no antistat or lubricant added, ran poorly and had a high sled test friction value (1750). The other sample (lot 4) with only 1% sodium acetate added processed without problems and had a sled test friction value of 970. Sodium acetate will not lower the friction value of the fiber (see Table A, lots 1 and 10). The difference could be due to non-uniform scouring (i.e., some areas of the fiber in the kier experienced higher alkali concentration removing all the oils and waxes, and other areas experienced lower alkali concentrations thereby leaving some of the natural oils and waxes). Therefore, the fiber in lot 10 may have received a near normal scour which removed most or all of the natural oils and waxes and would explain why it behaved like normal scoured and bleached fiber without finish (high static, high friction value, and poor cardability).

**Absorbency Data – Table A**

USP specifications state that the sink time must be less than 10 seconds. Many fiber finishes are good lubricants but interfere with absorbency. Using sink time and cardability as the criterion, only one of the finishes from this trial could be considered for USP applications, lot 6 which contained 0.25% BES and 1% sodium acetate on the weight of the fiber. Please note that the amount of sodium acetate added (1%) would need to be reduced to allow the fiber to pass the USP specification for water-soluble extractables.

The data indicated that BES should also be used for fiber that does not need to meet USP specifications, but still needs to be absorbent (experience has shown that the high level of BES, 1%, allows for better carding than the low level, 0.25%).

For use on fiber that does not need to meet USP specifications or maintain absorbency, the data shows that 1.7% Sebosan AS would be the recommended fiber lubricant.

## Effect of Mechanical Processing on Fiber Properties

Fiber properties were measured by HVI and AFIS (Table B). The fiber properties of samples from the finished lots before processing (i.e., after finishing at Littlewood) and labeled bale, B, were the only samples measured by HVI. The fiber properties were measured, using the AFIS, on samples taken before and during finished fiber processing from the bale, B; from card feed mat, FM; and after carding, CW. All fiber lots were measured by AFIS after carding at 30 pounds/hour; however, for lots 3, 6, 8, and 9 which were able to be carded at 75 pounds/hour, a second sample was taken at the higher production rate and tested.

The AFIS data in Table C shows that during pre-carding opening and cleaning, the fiber lots that had higher grams-force values also increased in short fiber content, increased in nep formation, and decreased in fiber length.

The AFIS data in Table D shows the changes in fiber properties due to carding. All but three fiber lots experienced increased short fiber content with carding. A trend between sled test grams-force values and increased short fiber content due to carding was not seen.

Carding decreased the upper quartile mean length of all fiber lots. In some instances, the upper mean length was reduced less at 30 pounds/hour than at 75 pounds/hour carding rates. These are not significant differences. One lot had no change at the higher production rate and one had longer length at the higher production rate.

Carding decreased the nep content in all lots expect one. The one lot that showed an increase in neps after carding was lot 7, which did not card at 30 pounds/hour. In all five cases where a higher production rate was achieved, the amount of neps removed during carding was less at the high production rate.

## Conclusions

1. One-percent sodium acetate added to the bleached cotton eliminated all measurable static during the carding process.
2. One-percent sodium acetate added to the bleached fiber allowed for the fiber to card at 45 pounds/hour where without it, the fiber would not card at 30 pounds/hour due to static.
3. One-percent sodium acetate does not lower the grams-force of the fiber as measured by the sled test.
4. The sled test results did not allow us to predict the cardability of the fiber in all cases. By using the sled test results, three lots – 2, 5, and 7 – would have been predicted to card well. However, these three lots would not card at 30 pounds/hour. The static meter indicated that there was no static present during carding. Therefore, the carding failure was due to a factor other than static.
5. There was a close trend between the upper grams-force values measured by Cotton Incorporated and the peak values measured by the University of Tennessee (UT).
6. The carding results from the USDA in Clemson correlate well with the visual carding assessments made at UT (Table A).
7. The two samples of low scoured cotton in this study were very different in the grams-force values measured by the sled test. Both fiber samples were taken from the same bale, and the only difference between the two was the sodium acetate content. It is known that sodium acetate does not decrease the grams-force measured by the sled test. One explanation may be that part of the fiber in the kier received a low scour leaving the natural oils and waxes, and the other received a normal scour, which would remove more natural oils and waxes.
8. For applications where USP grade bleached cotton is needed, the carding results show that 0.25% BES on the weight of the fiber would be the best choice. It should be noted that the amount of sodium acetate used in this test would need to be reduced to allow the USP water-soluble extract to be less than 0.35%.
9. Fiber applications where USP specifications do not apply but absorbency is required, BES would be the recommended finish. Levels of BES from 0.25% to 1.0% on the weight of the fiber could be used. Past experience has shown that 1.0% BES allows for better processing.
10. Applications where the fiber need not meet USP specifications or maintain absorbency, the recommended finish would be 1.7% Sebosan AS. It has very good lubricity (low grams-force) so it may be possible to reduce further the amount used and still get good results.
11. In the opening and cleaning line, the fiber lots with higher sled test values had larger increases in short fiber content and nep formation and the largest decreases in fiber length.
12. All the lots of bleached fiber experienced increases in short fiber content during carding except for two, which had no change.
13. No trend was noted where higher sled test values yield greater increases in short fiber content due to carding.
14. Carding decreased the upper quartile mean length of all fiber lots at 30 pounds/hour.
15. In three out of four fiber lots that were carded at 75 pounds/hour, the upper quartile mean lengths were decreased more than the fiber carded at 30 pounds/hour. Therefore, the trend is higher carding production rates can cause more fiber breakage.
16. Carding decreased the nep content in all lots but one and that was a lot that did not process at 30 pounds/hour.
17. Carding removes more neps at lower production rates.

## Discussion

The sled test is very good at determining if bleached cotton has a finish on it. It has been used a great deal evaluating commercially bleached fiber finishes with BES. Enough experience was gained with two roll goods manufacturers where a correct prediction on when they would experience carding problems due to lack of lubrication (high grams-force values) could be made using the sled test. This was assuming that high values from the sled test would mean poor fiber processing (carding).

This assumption was not disproved by this work and was probably an accurate statement. By the same token, the assumption that lower sled test values mean better carding results, could not be made. The data from the sled test and real world carding did not correlate for three lots which had sled test values that were well within the range of what was determined processable, yet would not card at 30 pounds/hour.

Static was eliminated as a problem in this work by using sodium acetate. The sled test is a measure of fiber-to-fiber lubricity or friction. Could the missing element be fiber-to-metal friction testing? Or could it be that each individual finish will need to be evaluated to determine the sled test values that will allow for carding?

The sled test is still a good screening test. Fiber finishes that yield sled test values above 1700 or 1800 on bleached cotton will present problems in carding. Fiber finishes that yield sled test values below 1700 or 1800 on bleached cotton may or may not run. The data presented indicates that fiber with sled test values below 1700 to 1800 have a possibility of carding well, but for unknown finishes, only a real world carding trial will determine the cardability of the fiber.

Table A. Fiber Lubricity (Sled Test), Fiber Cardability and Absorbency Data

| | | Sled Test (g-force) | | | | Carding Results | | | USP Absorbency[4] | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Cotton Incorporated | | | | Clemson – USDA | | Univ. of TN | Sink | Capacity |
| Lot No. | Finish[5] | Upper | Lower | Scroop | Univ. of TN Upper Only | Production Rate | Reason for Failure | Visual Assessment | Time (Sec) | (g. water per g. fiber) |
| 1 | 1.0% Sodium Acetate | 2050 | 0 | 0 | 2000 | Failed at 60 lbs/hr | Cylinder Loading | OK | 2.2 | 26.8 |
| 2 | 0.5% Armak 1336<br>1.0% Sodium Acetate | 1550 | 1250 | 300 | 1320 | Failed at 30 lbs/hr | No Cohesion – Web Coming Apart and Sticking to Rolls | BAD | 7.2 | 23.8 |
| 3 | 1.0% BES<br>1.0% Sodium Acetate | 1010 | 0 | 0 | 900 | No Problems at 75 lbs/hr | No Failure | EXCELLENT | 16.1 | 23.6 |
| 4 | Low Scour Fiber<br>1.0% Sodium Acetate | 970 | 0 | 0 | 890 | No Problems at 75 lbs/hr | No Failure | EXCELLENT | >60 | NM |
| 5 | 9.1% Sonostat 668<br>1.0% Sodium Acetate | 1100 | 0 | 0 | 980 | Failed at 45 lbs/hr | Cylinder Loading | GOOD | >60 | NM |
| 6 | 0.25% BES<br>1.0% Sodium Acetate | 1330 | 1120 | 210 | 1010 | No Problems at 75 lbs/hr | No Failure | GOOD | 5.9 | 24.5 |
| 7 | 0.8% Standard Soap<br>1.0% Sodium Acetate | 1320 | 1090 | 230 | 1190 | Failed at 30 lbs/hr | Cylinder Loading | BAD | 18.3 | 23.6 |
| 8 | 1.7% Sebosan AS<br>1.0% Sodium Acetate | 970 | 0 | 0 | 890 | No Problems at 75 lbs/hr | No Failure | EXCELLENT | >60 | NM |
| 9 | 1.7% Sebosan AS<br>0.5% Praelanol OK<br>1.0% Sodium Acetate | 970 | 0 | 0 | 910 | No Problems at 75 lbs/hr | No Failure | EXCELLENT | >60 | NM |
| 10 | NONE | 2050 | 0 | 0 | 1920 | Failed at 30 lbs/hr | Static | BAD | 2.2 | 27.1 |
| 11 | NONE, Low Scour Fiber | 1750 | 0 | 0 | 2170 | Failed at 30 lbs/hr | Static | BAD | 2.3 | 26.7 |
| 12 | NONE, Raw Cotton, Natural Finish | 850 | 0 | 0 | 800 | No Problems at 75 lbs/hr | No Failure | EXCELLENT | >60 | NM |

1. Lots 1, 2, 3, 5, 6, 7, 8, 9, 10 – All Normal Scoured and Bleached Fiber
2. Lots 4 and 11 – Low Alkali Scoured and Normal Bleached Fiber (low scour leaves some of the natural oils and waxes)
3. Lot 12 – Raw Cotton
4. Sink times stopped after 60 seconds. NM = Not Measured
5. Finish levels represent the amount of as received finish on the weight of the fiber (OWF).Table B. Fiber Properties

Table B. Fiber Properties

| Lot No. | Location* | AFIS Neps/Gram | AFIS Length (in) | AFIS % Short Fiber | AFIS Upper Quartile Length (in) | HVI Length (in) | HVI % Short fiber | HVI Strength (g/tex) | HVI Micronaire |
|---|---|---|---|---|---|---|---|---|---|
| 1 | B | 480 | 0.84 | 12.9 | 1.04 | 1.00 | 19.6 | 22.6 | 5.5 |
| | FM | 764 | 0.76 | 18.1 | 0.94 | -- | -- | -- | -- |
| | CW – 30#/hr | 190 | 0.69 | 23.2 | 0.85 | -- | -- | -- | -- |
| 2 | B | 465 | 0.86 | 10.5 | 1.07 | 1.09 | 10.8 | 22.4 | 5.4 |
| | FM | 601 | 0.85 | 11.7 | 1.04 | -- | -- | -- | -- |
| | SW – 30#/hr | 224 | 0.80 | 12.9 | 0.99 | -- | -- | -- | -- |
| 3 | B | 486 | 0.83 | 15.8 | 1.02 | 1.09 | 12.6 | 23.4 | 5.3 |
| | FM | 630 | 0.81 | 12.9 | 1.04 | -- | -- | -- | -- |
| | CW – 30 #/hr | 176 | 0.81 | 13.9 | 0.99 | -- | -- | -- | -- |
| | CW – 75#/hr | 229 | 0.81 | 13.6 | 1.00 | -- | -- | -- | -- |
| 4 | B | 503 | 0.90 | 9.9 | 1.12 | 1.12 | 11.9 | 25.3 | 4.8 |
| | FM | 703 | 0.88 | 10.5 | 1.09 | -- | -- | -- | -- |
| | CW – 30#/hr | 266 | 0.86 | 11.1 | 1.06 | -- | -- | -- | -- |
| | CW – 75 #/hr | 286 | 0.86 | 11.2 | 1.06 | -- | -- | -- | -- |
| 5 | B | 404 | 0.88 | 10.9 | 1.09 | 1.12 | 11.3 | 24.1 | 5.7 |
| | FM | 533 | 0.86 | 11.8 | 1.07 | -- | -- | -- | -- |
| | CW – 30#/hr | 172 | 0.85 | 11.8 | 1.06 | -- | -- | -- | -- |
| 6 | B | 429 | 0.88 | 10.3 | 1.08 | 1.10 | 10.3 | 23.3 | 5.7 |
| | FM | 652 | 0.88 | 10.0 | 1.07 | -- | -- | -- | -- |
| | CW – 30#/hr | 186 | 0.87 | 10.7 | 1.07 | -- | -- | -- | -- |
| | CW – 75#/hr | 286 | 0.86 | 11.1 | 1.05 | -- | -- | -- | -- |
| 7 | B | 543 | 0.85 | 11.9 | 1.05 | 1.08 | 10.6 | 23.4 | 5.4 |
| | FM | 604 | 0.82 | 14.0 | 1.02 | -- | -- | -- | -- |
| | CW – 30#/hr | 783 | 0.77 | 18.0 | 0.96 | -- | -- | -- | -- |
| 8 | B | 408 | 0.85 | 11.8 | 1.05 | 1.09 | 11.4 | 23.5 | 5.3 |
| | FM | 562 | 0.86 | 11.4 | 1.05 | -- | -- | -- | -- |
| | CW – 30#/hr | 179 | 0.85 | 11.4 | 1.04 | -- | -- | -- | -- |
| | CW – 75#/hr | 303 | 0.82 | 13.1 | 1.00 | -- | -- | -- | -- |
| 9 | B | 447 | 0.85 | 12.5 | 1.05 | 1.08 | 10.9 | 23.5 | 5.3 |
| | FM | 577 | 0.85 | 12.8 | 1.05 | -- | -- | -- | -- |
| | CW – 30#/hr | 203 | 0.84 | 12.6 | 1.04 | -- | -- | -- | -- |
| | CW – 75#/hr | 358 | 0.82 | 13.6 | 1.02 | -- | -- | -- | -- |
| 10 | B | 490 | 0.84 | 12.1 | 1.04 | 1.00 | 17.4 | 23.4 | 5.1 |
| | FM | 724 | 0.76 | 18.1 | 0.95 | -- | -- | -- | -- |
| | CW – 30#/hr | 365 | 0.73 | 19.8 | 0.90 | -- | -- | -- | -- |
| 11 | B | 440 | 0.82 | 14.0 | 1.01 | 1.00 | 18.3 | 23.1 | 5.3 |
| | FM | 632 | 0.79 | 15.1 | 0.98 | -- | -- | -- | -- |
| | CW – 30#/hr | 285 | 0.75 | 17.1 | 0.92 | -- | -- | -- | -- |
| 12 | B | 293 | 0.88 | 9.1 | 1.08 | 1.07 | 10.7 | 25.7 | 5.1 |

*B= Bale; FM=Feed Mat; CW=Card Web

Note: Samples from Lot 12 from the Feed Mat and Card Web were not available for testing.

Table C. Change in Fiber Properties Due to Pre-Carding Opening and Cleaning (AFIS)

| Lot No. | Sled Test (g-force) Upper Value | % Change in Short Fiber Content | % Decrease in Length Upper Quartile Mean | % Change in Neps |
|---|---|---|---|---|
| 1 | 2050 | 40 | -10 | +59 |
| 2 | 1550 | 11 | -3 | +29 |
| 3 | 1010 | -18 | +2 | -30 |
| 4 | 970 | 6 | -3 | +40 |
| 5 | 1100 | 8 | -2 | +32 |
| 6 | 1330 | -3 | -1 | +52 |
| 7 | 1320 | 18 | -3 | +11 |
| 8 | 970 | -3 | 0 | +29 |
| 9 | 970 | 2 | 0 | +29 |
| 10 | 2050 | 41 | -9 | +48 |
| 11 | 1750 | 8 | -3 | +44 |

Change in fiber properties calculated from bleached bale samples vs. card feed mat samples.

Table D. Changes in Fiber Properties Due to Carding (AFIS)

| Lot No. | Sled Test (g-force) Upper Value Cotton Incorporated | Card Production Rate (lbs/hr) | % Change in Short Fiber Content | % Decrease in Length | % Change in Neps |
|---|---|---|---|---|---|
| 1 | 2050 | 30 | -28.2 | 9.6 | -75.1 |
| 2 | 1550 | 30 | -10.3 | 4.8 | -62.7 |
| 3 | 1010 | 30 | -7.8 | 4.8 | -72.1 |
| | | 75 | -5.4 | 3.8 | -63.7 |
| 4 | 970 | 30 | -5.7 | 2.8 | -62.1 |
| | | 75 | -6.7 | 2.8 | -59.3 |
| 5 | 1100 | 30 | 0 | 0.9 | 67.7 |
| 6 | 1330 | 30 | -7.0 | 0 | -71.5 |
| | | 75 | -11.0 | 1.9 | -58.9 |
| 7 | 1320 | 30 | -28.6 | 5.9 | +11.2 |
| 8 | 970 | 30 | 0 | 1.0 | -68.1 |
| | | 75 | -14.9 | 5.0 | -46.1 |
| 9 | 970 | 30 | +1.6 | 1.0 | -64.8 |
| | | 75 | -6.2 | 2.9 | -38.0 |
| 10 | 2050 | 30 | +9.4 | 5.3 | -50.0 |
| 11 | 1750 | 30 | +13.2 | 6.1 | -54.9 |

Change in fiber properties calculated from feed mat samples vs. card web samples.

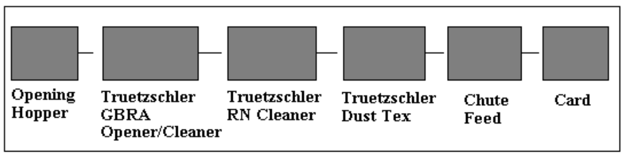


Figure 1. Fiber processing sequence used at USDA - Clemson.

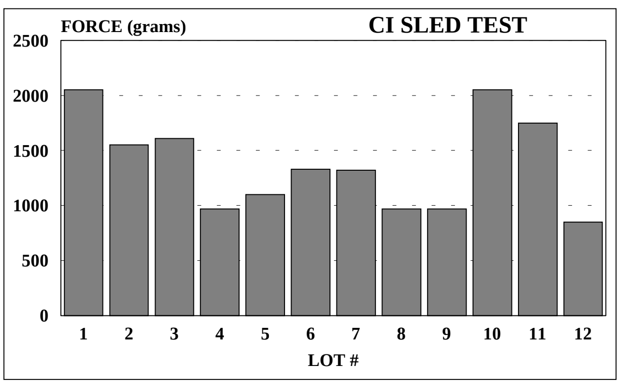


Figure 2. CI sled test results.

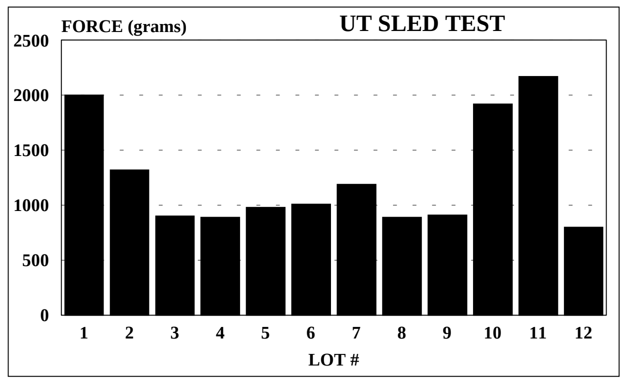


Figure 3. UT sled test results.

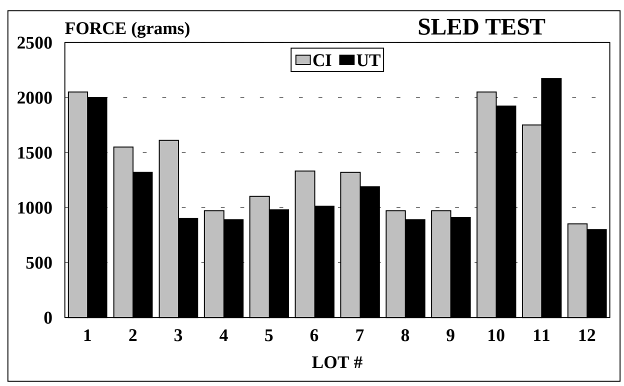


Figure 4. Comparison of CI and UT sled tests.