2005 Beltwide Cotton Conferences, New Orleans, Louisiana - January 4 - 7, 2005

MOISTURE TRANSFER WITH STRIP AND MICROPORE BALE BAGGING

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Abstract

As bale storage and handling practices change and new technology emerges, new types of bagging and ties are developed in response to the new requirements. The new materials are investigated to ensure that they perform satisfactorily before widespread use. The materials are studied under accelerated conditioning at high or low humidity in order to quickly assess the response of the new materials prior to commercial testing. The purpose of this study was to determine if a new style bale bag transferred moisture as well as the bags currently used in the United States. Three universal density bales were placed in each of three types of bale bags: 1) fully coated with uniformly spaced pinholes added (micropore), 2) fully coated, and 3) 3-inch wide, strip coated. The bales were stored for 179 days at 75% relative humidity (RH) and 75 °F. The micropore covered bales gained 1.7% (8.5 lbs) while the 3-inch-stripe bagged bale gained 2.1% (10.5 lbs.). Thus, the micropore bagging gains moisture more slowly than the conventional bag and will require about three weeks longer storage to achieve the same moisture levels as conventional bags. In short, the micropore bagging offers excellent bale protection at a lower moisture transfer rate.

Introduction

The change in the cotton industry to net weight trading opened the door to numerous advancements in lightweight bale bagging and ties. This change was brought about by the Joint Cotton Industry Bale Packaging Committee (JCIBPC) to improve the physical condition of cotton bales produced in the United States. For marketing based on gross weight, the heavy packaging materials offered considerable economic advantage. For example, in 1968 bales were covered in jute and restrained by flat steel bands with a tare weight of 21 lbs. However, most bales are now packaged in woven polypropylene or polyethylene film and restrained with wire ties, and have a tare weight of less than 5 lbs. As bale storage and handling practices change and new technology emerges, new types of bagging and ties are developed in response to the new requirements. The JCIBPC thoroughly investigates new bagging and tie materials to ensure that they perform satisfactorily before approving widespread commercial use. Some of the initial evaluation of the new materials is done at the U.S. Cotton Ginning Laboratory at Stoneville, MS. The Stoneville studies usually involve accelerated conditioning at high or low humidity in order to quickly assess the response of the new materials prior to commercial testing.

After the cotton fiber is packaged into a bale, moisture transfer occurs very slowly especially at high densities as the bales attempt to reach equilibrium with the environment (Anthony, 1982). The rate of adsorption and desorption is influenced by bale density, ambient temperature and humidity, bale covering, surface area, air changes, fiber history, etc. (Anthony, 1997). Anthony (1982) stored low-moisture bales for periods up to one year in jute, burlap, woven polypropylene, strip-laminated woven polypropylene, dimpled polyethylene and polyethylene bagging. Bales covered in the relatively impermeable polyethylene required much more time (over 365 days) to equilibrate with the environment than the other bale coverings (over 120 days).

The moisture transfer characteristics of universal density bales in burlap, woven polypropylene with laminated strips of polyethylene to prevent fibrillation, and polyethylene with 3/8-in. diameter perforations on 18-in. centers to allow air to escape during bag emplacement were studied by Anthony and Herber (1991). The bales were packaged at 3.5% moisture and stored at 70 ºF and 80% RH. They reported that the woven polypropylene-covered bales reached equilibrium in less than 161 days, whereas the polyethylene-covered bales had not reached equilibrium after 378 days. After 161 days, the polyethylene-covered bales had gained only about 40% as much moisture as the polypropylene-covered bales. Barker and Laird (1993) reported that desorption occurs at about twice the rate of adsorption for small samples of lint. Thus, bales should lose moisture much faster than they gain moisture.

In 2002, U.S. bales were packaged mostly in woven polypropylene (strip-coated or fully coated) (53%), polyethylene (39%), and burlap, (8%) (Thompson, 2003). The cotton industry is seeking a bagging that does not allow foreign matter to enter, but does allow moisture transfer. These two features are not compatible in the same bagging, thus a compromise must be reached in permeability. The traditional strip-coated woven polypropylene bag is strong and allows adequate moisture transfer. The traditional, relatively impermeable polyethylene bag limits contamination from dust and dirt but is weak and does not allow rapid moisture transfer. Merging these two features (strength and permeability) into one bagging can be accomplished by sacrificing some permeability and fully coating the interior (or exterior) of a woven polypropylene bag with a thin layer of polyethylene. However, this must be carefully done so that adequate permeability to moisture can be retained. In addition, bales are normally "stuffed" into the bale bag mechanically through the one open end, and the cotton bale rapidly displaces the air in the bag. As a result, a means for the air to exit must be provided. This can be done by cutting slots or holes near the sealed end of the bag or by omitting sections of the coating. Both of these alternatives are currently available. However, a newer bag has thousands of pinholes punched in the fabric to allow air to escape during stuffing and moisture to transfer during storage.

Purpose

The purpose of this study was to determine if a new style fully coated bale bag that has uniformly spaced pinholes for air release was better than other types of bags for moisture transfer.

Methodology

Nine bales of Stoneville 4892 variety cotton were ginned using standard ginning practices of dryer (250 ºF), cylinder cleaner, stick machine, cylinder cleaner, extractor-feeder/gin stand, and two saw-type lint cleaners. About 1,500 lbs of seed cotton was used for each bale. Samples included nine each for High Volume Instrument (HVI), lint moisture and Advanced Fiber Information System (AFIS) were taken from each bale. As bales were ginned, they were temporarily stored in sealed polyethylene bags until the test was completed.

Three bales were then placed in three types of woven polypropylene bale bags: 1) breathable bag with uniformly spaced pinholes (style 9722) (type 1) (Figures 1 and 2), 2) fully coated (style 9347) (type 2), and 3) 3-in. wide strip coated (style 9191) (type 3), and stored for 179 days at 75% relative humidity and 75 °F (Figure 3). They were weighed initially and then bi-weekly. The bales were weighed on a platform scale and moved to a different location in the storage room after each weighing. The thickness of the bales was measured at the "hump" using a special caliper (Figure 4). After the six-month storage period, three of the bales were weighed, opened, and samples taken from 20 layers within the bales. All HVI samples (before and after storage) were evaluated in random order during the same time frame at the Dumas Office, Cotton Division, Agricultural Marketing Services, U.S. Department of Agriculture. The remaining six bales were then stored under lower humidity conditions and the results will be reported later.

Results

The data collected during ginning is at Table 1. High Volume Instrument measurements were made by the Dumas Office of the Cotton Division, Agricultural Marketing Service, USDA. The bales were Middling light spot color with 34 staple and 4.7 micronaire. Weight, thickness, temperature and humidity means for the three bales with each type bagging are given in Table 2 for the 179-day storage period.

A third-order trend line was used to illustrate the weight change for bales stored in each type of bagging as shown in Figure 5. The bales followed the same trend but at different rates for each type bagging. The strip-coated (9191) bagging gained weight more rapidly than did the fully coated bagging (9347) and the micropore bagging (9722). Unfortunately, humidity dropped from the preferred 75% to as low as 55% between day 116 and day 146, and the change in humidity and its impact on bale weight is clearly shown in Figure 5. As can be readily observed, bale weight changed as the humidity changed. Bagging 9722 (micropore) seemed to lose weight much more quickly than the other bags.

Bale thickness values are plotted in Figure 6. Bale thickness at the hump was quite variable due to measurement techniques but followed the same pattern and trend as the bales gained weight (moisture) the bales expanded about 0.5 in.
Three of the bales were taken out of storage after 179 days, opened and sampled. Each bale was divided into 20 different layers (Figure 7) and 5 samples per layer for moisture and one for HVI were taken. The final lint moisture

is given in Table 5. Bales 1325 and 1334 were AMOCO style 9722, micropore, and bale 1332 was 3-in.-stripe bag style, 9191.

Initial moisture contents were 5.23%, 4.52% and 4.76%, respectively, for bales 1325, 1332 and 1334. Final lint moisture means for the three bales were 6.85%, 6.55% and 6.51%, respectively, for bales 1325, 1332 and 1334. Thus, the micropore-bagged bale gained 1.7% (8.5 lbs) while the 3-inch-stripe bagged bale gained 2.1% (10.5 lbs).

In a second phase of the study, six of the nine bales were moved to a low humidity conditioning room to evaluate their response to storage at 50% relative humidity. Results will be reported later.

Summary and Conclusions

The purpose of this study was to determine if a new style, fully coated woven polypropylene bale bag that has uniformly spaced pinholes for air release transferred moisture as well as the fully coated and strip laminated woven polypropylene bags currently used in the United States. Nine bales were ginned using standard ginning practices of dryer (250 ºF), cylinder cleaner, stick machine, cylinder cleaner, extractor-feeder/gin stand, and two lint cleaners. Three bales were placed in each of three types of bale bags: 1) breathable bag with uniformly spaced pinholes (style 9722) (type 1), 2) fully coated (style 9347) (type 2), and 3) 3-in. wide strip coated (style 9191) (type 3), and stored for 179 days at 75% relative humidity and 75 °F. They were weighed initially and then bi-weekly. After the six-month storage period, three of the bales were weighed, opened, and samples taken from 20 layers within the bales.

Final moisture contents for bales 1325 and 1334 (AMOCO style 9722, micropore), and bale 1332 (3-in.-stripe bag style 9191) were 6.85%, 6.51% and 6.55% moisture content, respectively. Since initial moisture contents were 5.23%, 4.52% and 4.76%, respectively, for bales 1325, 1334 and 1332, the micropore-bagged bale gained 1.7% (8.5 lbs) while the 3-in.-stripe bagged bale gained 2.1% (10.5 lbs). Thus, the micropore bagging gains moisture more slowly than the conventional bag and will require about three weeks longer storage to achieve the same moisture levels as conventional bags. The micropore bagging offers excellent bale protection at a lower moisture transfer rate.

Disclaimer

Mention of a trade name, propriety product or specific equipment does not constitute a guarantee or warranty by the United States Department of Agriculture and does not imply approval of a product to the exclusion of others that may be suitable.

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Table 1. Gin data and ginning condtions[1]

Ginid	Bagging style	Bale weight, lbs	Bagging type code	Lint moisture, %	Bale number
1	9722	493	1	5.23	1325
2	9347	487	2	4.95	1326
3	9722	487	1	4.50	1327
4	9191	492	3	4.67	1330
5	9347	486	2	4.57	1331
6	9191	484	3	4.52	1332
7	9347	492	2	4.50	1333
8	9722	503	1	4.76	1334
9	9191	492	3	4.80	1335

[1]Variety--STV 4892. Machinery sequence—Dryer (250 ºF), cylinder cleaner stick machine, cylinder cleaner, extractor-feeder gin stand, and 2 lint cleaners. Nine bale samples were taken for each HVI, LM, and AFIS. Three styles of woven polypropylene bags were used experimental bag from AMOCO (style 9722) (Type 1), approved fully coated bag style 9347 (Type 2), and 3-in. stripe bag, style 9191 (Type 3).

Table 2. Selected means for bale parameters for bales stored in three different types of bagging.

Type of bagging[1]	Days of storage	Weight change/500 lb.	Weight change, %	Thickness, in.	Temperature, ºF	Humidity, %
1	0	0.00	0.00	32.17	78	79
1	11	3.01	0.60	31.88	72	87
1	21	4.93	0.99	31.98	75	81
1	31	6.41	1.28	32.14	74	88
1	42	6.83	1.37	32.17	75	75
1	63	9.40	1.88	32.40	74	74
1	82	10.65	2.13	32.46	74	76
1	101	11.17	2.23	32.52	66	74
1	124	10.50	2.10	NA	75	54
1	144	10.02	2.00	32.46	76	82
1	161	11.15	2.23	32.53	75	61
1	179	11.20	2.24	32.41	75	70
2	0	0.00	0.00	32.15	78	79
2	11	2.02	0.40	31.63	72	87
2	21	3.08	0.62	31.67	75	81
2	31	4.45	0.89	31.75	74	88
2	42	4.73	0.95	31.86	75	75
2	63	7.32	1.46	32.13	74	74
2	82	8.47	1.69	32.13	74	76
2	101	9.09	1.82	32.32	66	74
2	124	9.21	1.84	NA	75	54
2	144	9.30	1.86	32.21	76	82
2	161	9.92	1.98	32.34	75	61
2	179	10.58	2.12	32.28	75	70
3	0	0.00	0.00	32.09	78	79
3	11	4.13	0.83	31.94	72	87
3	21	6.37	1.27	32.17	75	81
3	31	8.14	1.63	32.27	74	88
3	42	8.09	1.62	32.21	75	75
3	63	10.99	2.20	32.44	74	74
3	82	12.36	2.47	32.54	74	76
3	101	12.30	2.46	32.56	66	74
3	124	11.34	2.27	NA	75	54
3	144	11.12	2.22	32.46	76	82
3	161	12.30	2.46	32.54	75	61
3	179	11.98	2.40	32.49	75	70

[1]Type 1 = Amoco style 9722 with pinholes. Type 2 = Approved fully coated woven polypropylene bag, style 9347. Type 3 = Approved woven polypropylene bag with alternating 3-in. coated stripes.
NA = not available

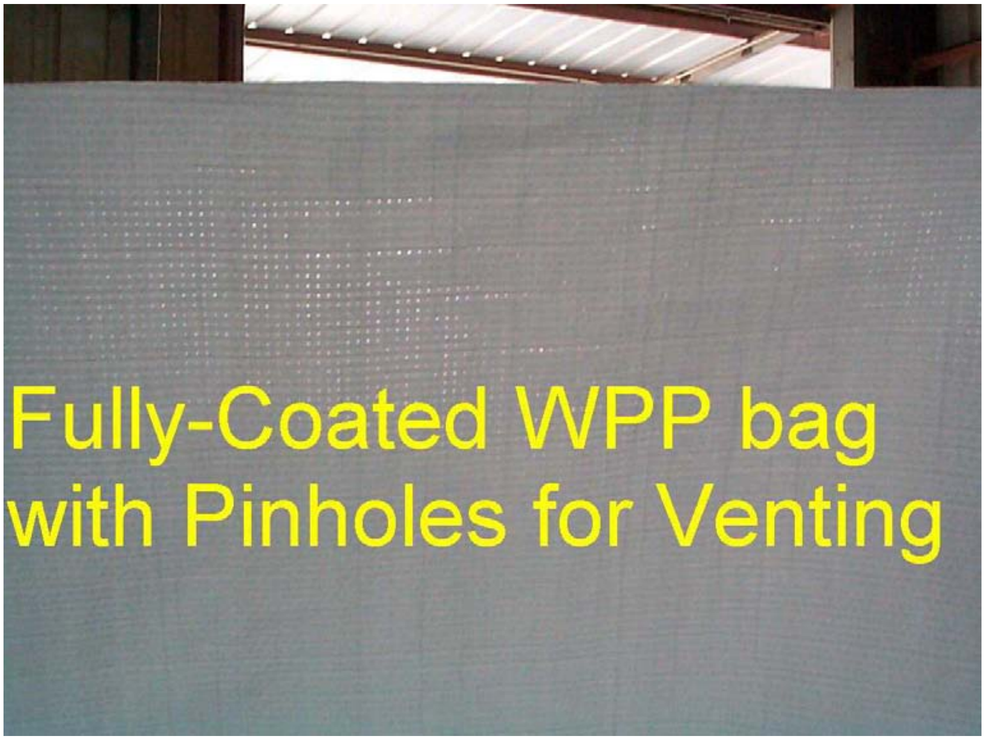

Figure 1. Fully coated bagging with pinholes (micropore, style 9722) punched to allow moisture transfer.

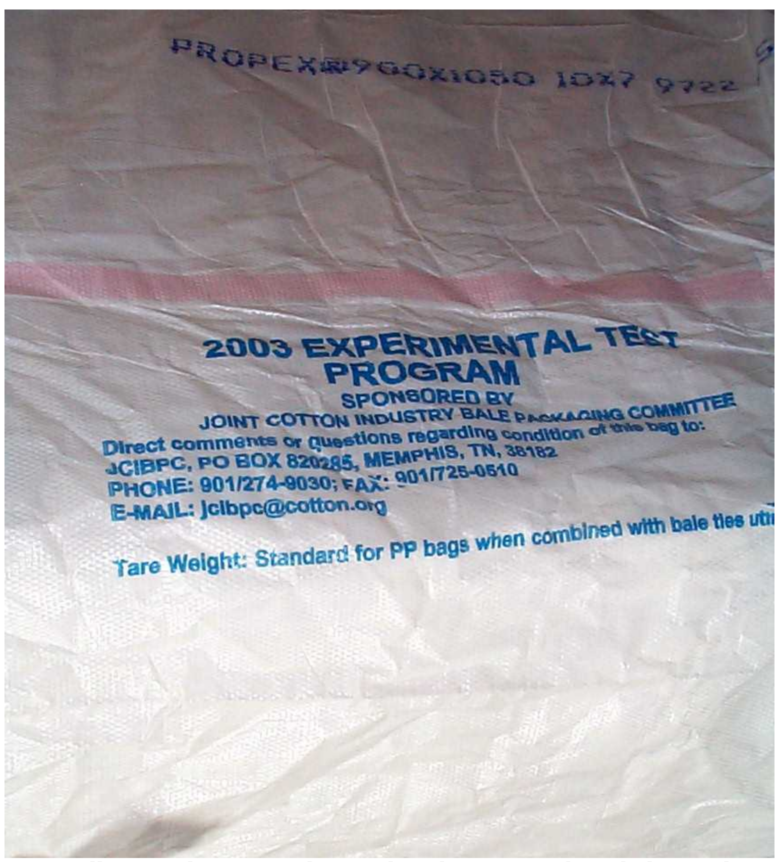

Figure 2. Fully coated woven polypropylene bagging with pinholes (style 9722).

Figure 3. Nine bales in storage at 75% relative humidity.

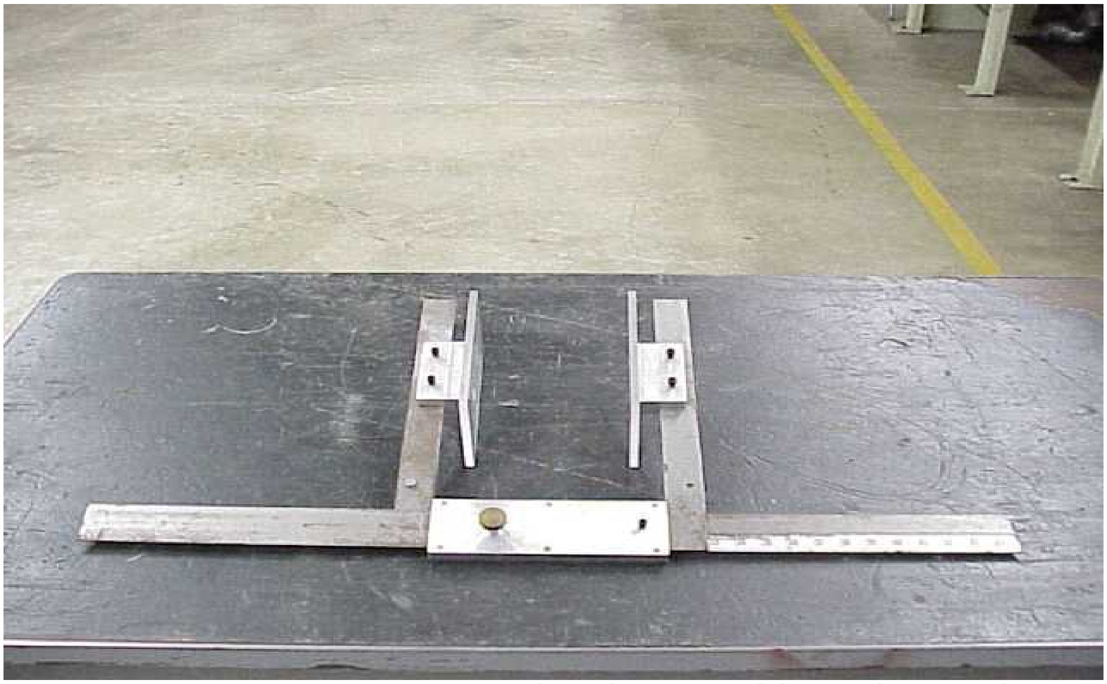

Figure 4. Two carpenters squares were joined together using a sliding mechanism with setscrews to enhance measurement of bale dimensions. Wide flanges were added to help measure the thickness at the hump.

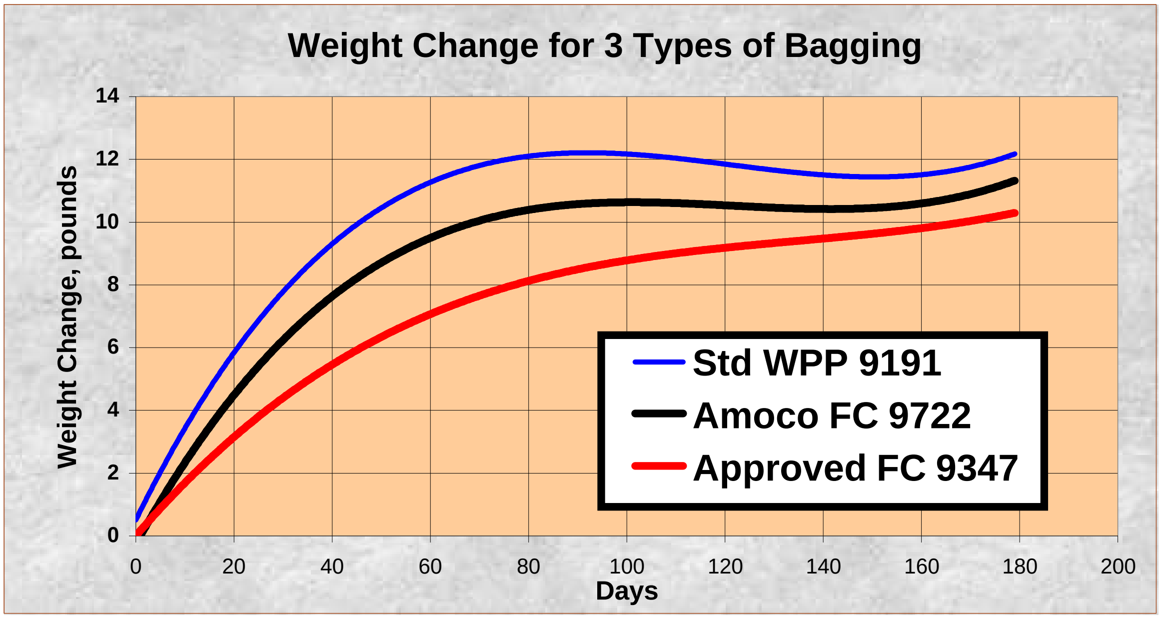

Figure 5. Weight change with time for bales stored at 75% relative humidity for 179 days. Note that humidity inadvertently changed from 75% to 55% from day 116 to day 146, and the bales lost weight during that time. Std WPP 9191 is the strip-coated woven polypropylene. Amoco FC 9722 is the fully coated woven polypropylene with uniformly spaced pinholes. Approved FC 9347 is fully coated woven polypropylene.

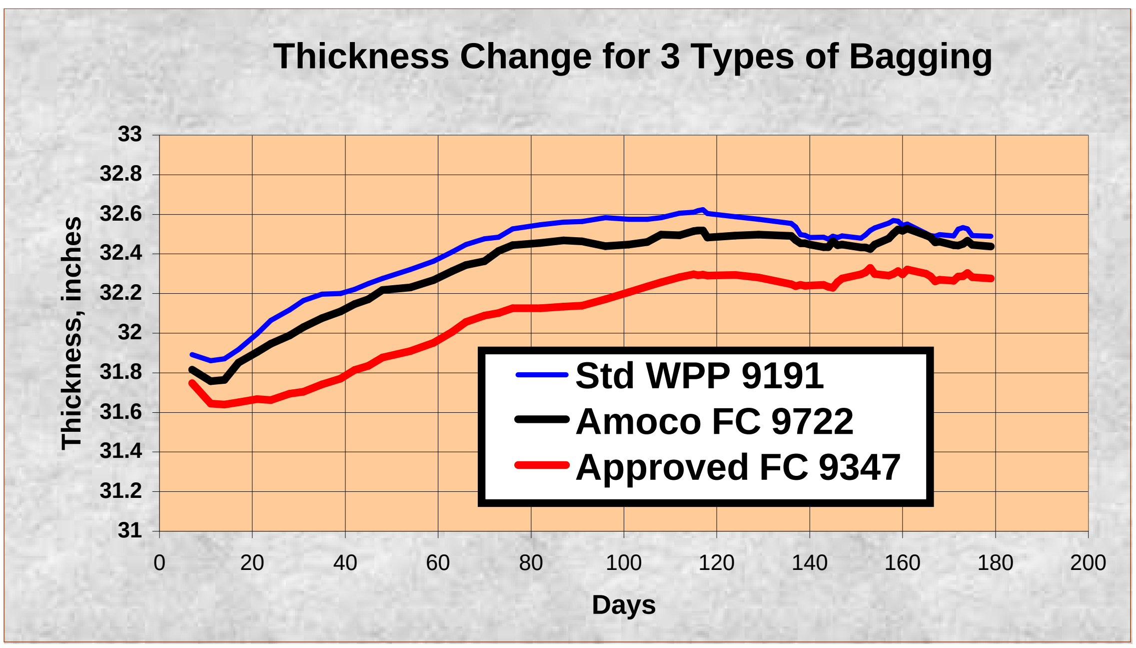

Figure 6. Change in thickness for bales stored in three types of bagging for 179 days at 75% relative humidity. Note that humidity inadvertently changed from 75% to 55% from day 116 to day 146, and the bales lost weight during that time. Std WPP 9191 is the strip-coated woven polypropylene. Amoco FC 9722 is the fully coated woven polypropylene with uniformly spaced pinholes. Approved FC 9347 is fully coated woven polypropylene.

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Figure 7. Three bales were divided into 20 layers at the locations shown and subsampled for moisture and grade.