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Excisions/Revisions
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LOG OF MEETING

SUBJECT: Removal of Cooking Oil from Cotton Terrycloth Towels

DATE: February 5, 1997

PLACE: Consumer Product Safety Commission, Bethesda, MD

NON-COMMISSION ATTENDEES:
Suvarna Rajguru, Baker & Hostetler, representing the Soap and Detergent Association
Patty Adair, National Cotton Council
Maureen Cislo, Product Safety Letter

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SUMMARY: The Soap and Detergent Association (SDA) recently reported on a study of the removal of cooking oil from cotton terrycloth towels. This report relates to the 1992 CPSC press release advising consumers of the risk of spontaneous combustion of towels soaked with vegetable cooking oils. The spontaneous combustion was shown to occur even after conventional laundering.

The SDA study evaluated the effects of varying detergent, wash water temperature, and pre-soak on the removal of cooking oil from cotton terrycloth towels. A copy of the report is attached. Generally, residual cooking oil remained after each of the experimental conditions. The most beneficial effect was found with a pre-soak. Evidence of the potential for combustion was found. No further work is planned at this time.

The Consumer Product Safety Commission's new Apparel project plans were briefly described by Ms. Neily, since CPSC will be evaluating a new "standard" detergent for possible substitution in several flammability standards for a now-unavailable "standard" detergent.

September 30, 1996
The Soap and Detergent Association

Removal of Cooking Oil from Cotton Terry Cloth Towels

Introduction

On September 12, 1991, the Whirlpool Corporation presented a report to the United States Consumer Product Safety Commission (CPSC) summarizing an investigation it had performed into the spontaneous combustion of laundry. The company began this investigation after a fire chief had informed Whirlpool of three fires over the previous two years resulting from the combustion of freshly laundered terry cloth towels taken from dryers and left in piles. Whirlpool received samples of material from one of the incidents. Upon analysis, it was determined that a sample contained 30%, by weight, of vegetable oil.

Whirlpool then investigated the literature concerning combustion of oil and found that some edible oils were known to spontaneously combust. Whirlpool contacted an outside laboratory to perform modified Mackey tests for evaluation of self-combustibility. The test involves heating a sample to 100°C and checking for increases in sample temperature over a given period of time. These tests were run on terry cloth soaked with vegetable oil. In addition, Whirlpool performed tests in its own laboratory to evaluate the combustibility hazard from machine drying of oil-soaked fabrics. All tests showed self-heating or combustion of samples soaked with vegetable oil. Towels made with synthetic fibers did not exhibit this phenomenon.

Whirlpool concluded that the effect was not due to mechanical defects in the washers or dryers. The company also hypothesized that the occurrence of this phenomenon could increase as consumers switch to vegetable oils for dietary reasons; household hot water temperature is reduced to conserve energy; the use of cold and warm water wash cycles increases; and the incomplete or reduced oil removal by detergents due to reformulation (1).

The CPSC then performed its own tests and issued a consumer advisory in January 1992 recommending the use of paper towels to clean up large cooking oil spills. The Commission stated that normal laundering may not remove all of the oil. However, the Commission acknowledged that use of paper towels is also hazardous and the CPSC recommended that the paper towels should not be tightly packed in the trash container, nor should they be exposed to heat sources such as sunlight, space heaters, ovens or stoves (2). The CPSC also asked that affiliated industries investigate the phenomenon.

Historically, the SDA has recommended procedures for removing oily and greasy stains from fabrics (3). However, the procedures were for removal of small amounts of oil for aesthetic purposes, not to prevent spontaneous combustion of fabrics soaked with oil. The industry lacked information documenting the amount of oil that might remain in the cloth after laundering. Therefore, the Association set out to investigate the best methods for either complete removal of oil, or removal of enough oil to prevent spontaneous combustion of the laundry.

In a preliminary study, a terry cloth towel absorbed large amounts of oil, at least three times its own weight. In addition, small amounts of oil (1 ounce) on a single towel were easily removed. In the same experiments, it was also determined that weighing towels yielded the same

results as extracting the oil from the towels and measuring the amount. SDA decided to perform more experiments that would indicate whether detergent type (liquid or powder), presoaking, or wash temperature would influence oil removal. It was decided that the washing should be performed at high water hardness levels to simulate the most unfavorable laundering conditions. In addition, two levels of oil (moderate and high) were administered to the wash bundles.

Materials and Methods

Materials

New terry cloth kitchen towels made of 100% cotton were used in the study (Fieldcrest Cannon, Inc., Kannapolis, NC. #0 441300; color Br36 Berber Beige). Soybean oil (100%) and prototype powder and liquid laundry detergents (as described in Table 1) were provided by The Procter & Gamble Company, Cincinnati, OH. Soybean oil is the most widely used cooking oil in the United States.

Test Conditions

All work was performed by United States Testing Company, Inc., Hoboken, NJ. Individual towels were soaked with 6 fluid ounces of oil. Four or eight towels were used to make up the towel subunits and to equal a total of 24 or 48 ounces of oil in each wash load. All conditions were performed in triplicate. Additional clean towels were added to make a total fabric weight of approximately 2.5 kg per bundle. Twelve wash conditions were used as listed in Table 2: with or without presoak; at wash temperatures of 70°F, 100°F, or 130°F; using either the liquid or powder detergent. Water hardness was set at 165 ppm calcium carbonate for the wash cycle. Each wash condition listed in Table 2 was performed once with an additional bundle that did not contain oil to control for background weight changes. All towels were line dried.

Determination of Residual Oil

Since fabric fibers are lost from new fabrics and oil removal was to be based on weight measurement, all towels were washed a minimum of 5 times prior to use in any experiment to achieve stable towel weight (± 0.5% change). Weights of individual towels were determined prior to the experimental wash (prior to any presoak), for the four or eight oil-containing towels subunits, and for the whole wash bundle. Similar weight determinations were made after the towels had been laundered and dried. The percent residual oil (%RESID) and the percent removal of oil (%REM) were calculated using the following formulae:

$$\%RESID = \frac{(\text{final weight} - \text{original clean weight})(100)}{\text{final weight}}$$

$$\%REM = \frac{(\text{original oiled weight} - \text{final weight})(100)}{\text{original oiled weight} - \text{original clean weight}}$$

Determination of Flammability

In order to determine the flammability of laundered towels with residual oil, two additional sets of four towels were loaded with 6 ounces of oil each for a total of 24 ounces of oil. These towels were washed with either powder or liquid detergent at 100°F and water hardness of 165 ppm calcium carbonate. One oiled towel was divided in half, with one half used in the Mackey test. The other half and the remaining towels were reserved for use in peroxide value determinations following petroleum ether extraction.

Mackey test results (4) and peroxide values were also determined for fresh soybean oil (used to load the laundered towels); two stored samples of soybean oil (opened and unopened); and USP soybean oil (untreated and hot petroleum ether extracted). The peroxide values were determined in accordance with the American Oil Chemists' Society (AOCS) method Cd 8-53 (5).

The Mackey test for spontaneous heating was performed following Federal Test Method Standard No. 191A (modified). The individual oils were tested by applying 14 g of oil to 7 g of rolled cotton. The chamber was heated to approximately 208°F (98°C) and the temperature of the sample was measured every 30 minutes for several hours. Any rise in temperature over the ambient temperature (208°F) is an indication that the test material has the potential for self heating.

Results and Discussion

The laundering results are presented in Tables 3 to 11. The control wash results, in Tables 3, 6, and 9, indicate that there were minor changes in the weights following laundering. The wash loads with 24 and 48 ounces of added oil also showed variability in results due to the variation in towel weights, variation in the exact amount of oil applied, and variation due to uncontrollable factors inherent to the laundering process. Means for each measurement are presented with the standard deviation for each measurement. The towel subunits (Tables 6-8) represent eight towels for the controls and 48 ounce group, and four towels for the 24 ounce group.

In all three types of measure (individual towels, towel subunit, bundle), the loading of more oil to the wash generally resulted in higher values of residual oil ($p<0.001$). Only when presoaked and washed at 130°F with a powder detergent was the 48 ounce value below the 24 ounce value. In no case did the wash loads with oil approach the change in percentage for the control wash load. The percent of residual oil was lower for the bundles with 24 ounces of oil (2%-5%) and slightly higher for the bundles with 48 ounces of oil (4%-8%). The individual towels had residual percentages in the 6% to 9% range when 24 ounces of oil was applied, and 7% to 12% when 48 ounces of oil was applied. These individual towel values are reflected in the ranges for the four and eight towel subunits where the percentage of residual oil in the wash loads with 24 ounces of oil were in the 7% to 9% range, and the percentage of residual oil in the towel subunits with 48 ounces of added oil was in the 7% to 15% range.

The bundles had 80% to 90% of the oil removed, while the oil soaked towels (individually and grouped into four or eight towel subunits) had greater than 95% of the oil removed. The percentage residual oil was 2% to 5% for the bundles. Comparing the individual

towels to the towel subunits then to the whole bundle, the weight of residual oil in the bundle cannot be explained only by the amount left on the oiled towels. While the amount of residual oil on the towels can be added together to get the subunit residual weight, the subunit residual weight does not account for the entire bundle residual weight. When 24 ounces of oil was added to a bundle, the bundle had 3 to 6 times the residual oil than that of the oil-soaked towel subunits. In addition, the 48 ounce loading resulted in 2 to 3 times the residual in the bundle compared to the subunit.

Detergent selection had only a marginal effect on residual oil levels ($p=0.04$), with the liquid slightly outperforming the powder. However, this difference did not occur when presoaking was performed. In almost all cases, the presoak values are lower than the values from unsoaked wash loads ($p<0.001$). In addition, higher wash temperatures did not have a statistically significant effect on residual oil levels ($p=0.9$). This was unexpected, and was opposite to the effects on the control wash loads, which generally had lower, even negative values for weight gain after laundering at higher temperatures.

In order to determine the effects that laundering would have on the flammability of the oils, individual oils were analyzed. As indicated in Table 12, the peroxide values for the stored unopened oil were the same as for the USP Soybean Oil. However, new oil had lower peroxide values, and opened stored oil had higher values. All values were surpassed by the oil extracted from the laundered towels. This indicates that the laundering and drying process oxidized the oil. However, no studies exist that demonstrate how oxidation of the oil might affect the potential for self-heating.

The Mackey test results indicated that all of the oil samples had the capability to self-heat. The stored open oil exhibited the greatest increase in temperature above ambient temperature; the new oil showed the least increase in temperature. Laundered towels with oil also exhibited a potential for self-heating, as evidenced by a rise in temperature above the ambient temperature.

Conclusion

The results indicate that the best way to clean a heavily oiled towel is to presoak the towel with detergent, then immediately wash the towel. This procedure will remove 97% of the oil from the towels. However, laundered towels with this residual level of oil still *have the potential to* exhibit the ability of self-heating, as do the vegetable oils handled in various ways. Transfer of the oil during laundering to previously unoiled fabric *can also occur*.

The relevance of the Mackey test for spontaneous heating to laundered towels previously soaked with oil is not clear. The test was developed to test the spontaneous combustion of oil (6,7). Its only known application today is as a federal government test method (4) to determine the tendency of cloth to undergo self-heating. There are apparently no studies demonstrating the use of the test to study the self-heating of oil soaked towels that have been laundered. Further, there have been no studies to show how the potential for self-heating, as measured by the Mackey test, relates to the actual occurrence of combustion.

References

1. Taylor, R. and Seib, R. Spontaneous combustion of vegetable oils on fabrics. presentation to the Consumer Product Safety Commission. September 12, 1991.

2. Hidden Hazard in the Home: cloths heavily soiled with vegetable oil can start fires. News from CPSC, January 6, 1992.

3. Fact Sheet Notebook - Laundering. 1991.

4. General Services Administration. Textile test methods: Federal test method Standard Number 191A (modified). Heating (spontaneous) of Cloth. Adopted July 20, 1978.

5. Official methods and recommended practices of the American Oil Chemists' Society. Determination of peroxide value. Number CD 8-53. American Oil Chemists' Society. Champaign, Illinois. 1986.

6. Gill, A. H. A Short Hand-Book of Oil Analysis. J.B. Lippincott Company, Philadelphia. 1927.

7. Lewkowitsch, J. Chemical Technology and Analysis of Oils Fats and Waxes. Macmillan and Company, Limited, London. 1915.

Table 1

Detergent formulations given as percentage of total

Ingredient	Liquid	Powder
Anionic Surfactant		
NaLAS	9.0	10.5
NaAES	8.0	
Nonionic surfactant	5.0	3.5
Sodium carbonate		40.0
Sodium silicate, solids		10.0
Sodium sulfate		30.0
Sodium citrate	4.0	
Sodium fatty acids	3.0	
Mono ethanolamine	2.0	
Ethanol	1.5	
Propane diol	3.0	
Other hydrotrope (as needed)	3.0	
Brightener		
Perfume		
Water (to balance)	61.5	6.0

Table 2

Conditions for the test of the effect of presoaking on the removal of cooking oil

Condition	Presoak	Wash Temperature (°F)	Detergent
A	No	70	Liquid
B	No	100	Liquid
C	No	130	Liquid
D	Yes	70	Liquid
E	Yes	100	Liquid
F	Yes	130	Liquid
G	No	70	Powder
H	No	100	Powder
I	No	130	Powder
J	Yes	70	Powder
K	Yes	100	Powder
L	Yes	130	Powder

Table 3

Weight changes in bundles without added oil

Wash Condition	Clean Bundle Weight (g)	Final Bundle Weight (g)	Weight Change	Percent Weight Change
A	2510.0	2529.0	19.0	1.0
B	2559.0	2562.0	3.0	0.0
C	2597.0	2600.0	3.0	0.0
D	2526.0	2526.0	0.0	0.0
E	2549.0	2569.0	20.0	1.0
F	2587.0	2589.0	2.0	0.0
G	2544.0	2582.0	38.0	2.0
H	2592.0	2613.0	21.0	1.0
I	2629.0	2607.0	-22.0	-1.0
J	2529.0	2563.0	34.0	1.0
K	2562.0	2592.0	30.0	1.0
L	2615.0	2608.0	-7.0	0.0

Table 4

Weight changes in bundles of towels originally containing 24 fluid ounces of vegetable oil.

Wash Condition	Clean Bundle Weight (g)	Oily Bundle Weight (g)	Final Bundle Weight (g)	Percentage of Oil Removed	Percent Residual Oil	Weight of Loaded Oil (g)	Weight of Residual Oil (g)
A	2572.3 ± 48.7	3253.3 ± 51.3	2675.6 ± 41.2	85.0 ± 2.2	4.3 ± 0.5	681.0 ± 6.2	103.3 ± 14.0
B	2563.6 ± 35.5	3241.0 ± 22.8	2669.3 ± 20.3	84.3 ± 2.1	4.0 ± 0.8	677.3 ± 13.0	105.6 ± 12.7
C	2536.6 ± 33.2	3223.6 ± 11.1	2636.3 ± 5.7	85.6 ± 1.2	4.0 ± 0.0	687.0 ± 1.4	99.6 ± 7.0
D	2572.3 ± 36.0	3256.0 ± 41.3	2627.0 ± 59.1	92.3 ± 4.2	2.0 ± 0.8	683.6 ± 1.2	54.6 ± 29.1
E	2506.3 ± 39.0	3187.0 ± 1.6	2570.6 ± 25.6	90.6 ± 3.3	2.6 ± 1.2	680.6 ± 1.7	64.3 ± 24.7
F	2538.3 ± 36.1	3219.3 ± 11.3	2618.0 ± 15.6	88.3 ± 1.7	3.3 ± 0.5	681.0 ± 1.4	79.6 ± 12.1
G	2613.0 ± 49.0	3295.6 ± 65.4	2707.0 ± 71.6	86.3 ± 2.5	3.3 ± 0.5	682.6 ± 8.2	94.0 ± 16.3
H	2535.6 ± 50.1	3217.0 ± 48.0	2651.0 ± 47.7	83.0 ± 0.8	4.3 ± 0.5	681.3 ± 5.7	115.3 ± 6.1
I	2526.3 ± 48.4	3213.6 ± 16.8	2664.0 ± 43.8	80.0 ± 5.7	5.0 ± 1.4	687.3 ± 1.2	137.6 ± 39.2
J	2537.0 ± 46.2	3221.6 ± 7.7	2621.0 ± 17.6	87.6 ± 1.9	3.3 ± 0.5	684.6 ± 1.7	84.0 ± 12.0
K	2552.6 ± 46.9	3242.3 ± 57.6	2631.0 ± 59.8	88.6 ± 3.1	3.0 ± 0.8	689.6 ± 6.1	78.3 ± 23.2
L	2513.0 ± 49.0	3197.0 ± 52.6	2651.6 ± 5.9	79.6 ± 9.1	5.3 ± 2.6	684.0 ± 5.7	138.6 ± 64.1

Table 5

Weight changes in bundles of towels originally containing 48 fluid ounces of vegetable oil.

Wash Condition	Clean Bundle Weight (g)	Oily Bundle Weight (g)	Final Bundle Weight (g)	Percentage of Oil Removed	Percent Residual Oil	Weight of Loaded Oil (g)	Weight of Residual Oil (g)
A	2564.0 ± 16.6	3960.3 ± 48.7	2725.0 ± 39.2	88.6 ± 1.2	6.0 ± 0.8	1396.3 ± 32.3	161.0 ± 22.9
B	2509.0 ± 49.7	3895.6 ± 53.6	2710.3 ± 132.4	85.6 ± 5.6	7.3 ± 2.6	1386.6 ± 10.9	201.3 ± 77.8
C	2534.0 ± 40.7	3906.3 ± 11.1	2693.6 ± 9.0	88.3 ± 1.2	5.6 ± 0.5	1372.3 ± 7.8	159.6 ± 10.9
D	2542.3 ± 38.0	3913.6 ± 22.0	2653.0 ± 28.4	92.3 ± 0.5	4.3 ± 0.5	1371.3 ± 7.5	110.6 ± 7.6
E	2556.3 ± 40.3	3927.3 ± 48.7	2661.0 ± 41.7	92.3 ± 0.9	4.3 ± 0.5	1371.0 ± 7.8	104.6 ± 16.5
F	2528.3 ± 37.8	3908.6 ± 22.6	2644.3 ± 14.8	91.6 ± 0.5	4.3 ± 0.5	1380.3 ± 6.2	116.0 ± 4.1
G	2559.0 ± 39.5	3937.3 ± 48.9	2776.0 ± 66.5	84.3 ± 2.5	8.0 ± 1.4	1378.3 ± 4.2	217.0 ± 38.8
H	2535.3 ± 38.5	3852.0 ± 95.1	2731.6 ± 19.1	84.6 ± 2.1	7.3 ± 0.9	1316.6 ± 88.3	196.3 ± 15.4
I	2576.6 ± 38.0	3944.3 ± 5.4	2745.3 ± 8.6	87.6 ± 0.5	6.0 ± 0.0	1367.6 ± 0.5	168.6 ± 3.9
J	2543.3 ± 36.4	3897.6 ± 3.3	2644.0 ± 18.7	92.6 ± 1.2	4.0 ± 0.8	1354.3 ± 19.5	114.0 ± 8.0
K	2547.0 ± 35.2	3914.3 ± 18.8	2645.0 ± 22.8	92.6 ± 0.9	3.6 ± 0.5	1367.3 ± 2.6	98.0 ± 14.9
L	2547.0 ± 33.7	3910.3 ± 8.1	2661.0 ± 11.2	91.6 ± 0.5	4.3 ± 0.5	1363.3 ± 5.7	114.0 ± 8.0

Table 6

Weight changes in eight towel subunits without added oil.

Wash Condition	Clean Unit Weight (g)	Final Unit Weight (g)	Weight Change	Percent Weight Change
A	422.0	424.0	2.0	1.0
B	424.0	425.0	1.0	0.0
C	419.0	425.0	7.0	2.0
D	419.0	422.0	3.0	1.0
E	425.0	430.0	5.0	1.0
F	415.0	417.0	2.0	1.0
G	429.0	437.0	9.0	2.0
H	423.0	427.0	3.0	1.0
I	448.0	447.0	-1.0	0.0
J	420.0	425.0	5.0	1.0
K	423.0	430.0	6.0	2.0
L	427.0	424.0	-2.0	-1.0

Table 7

Weight changes in six towel subunits originally containing 24 fluid ounces of vegetable oil.

Wash Condition	Clean Unit Weight (g)	Oily Unit Weight (g)	Final Unit Weight (g)	Percentage of Oil Removed	Percent Residual Oil	Weight of Loaded Oil (g)	Weight of Residual Oil (g)
A	285.3 ± 74.4	967.0 ± 7.8	311.3 ± 3.4	96.3 ± 0.5	8.6 ± 0.5	681.0 ± 6.2	25.6 ± 1.2
B	288.6 ± 71.7	966.0 ± 17.3	314.0 ± 4.5	96.3 ± 0.5	8.0 ± 0.8	677.3 ± 13.0	25.3 ± 2.9
C	282.0 ± 71.6	968.6 ± 0.9	302.0 ± 4.1	97.3 ± 0.5	7.0 ± 0.8	687.0 ± 1.4	20.3 ± 2.9
D	285.3 ± 71.8	968.6 ± 4.9	304.6 ± 6.8	97.3 ± 0.5	6.6 ± 0.9	683.3 ± 0.9	19.3 ± 2.9
E	279.6 ± 71.8	960.3 ± 2.5	299.0 ± 6.2	97.3 ± 0.5	6.6 ± 1.9	680.6 ± 1.7	19.6 ± 4.7
F	280.6 ± 71.9	961.3 ± 3.4	302.3 ± 3.9	97.0 ± 0.0	7.3 ± 0.9	681.0 ± 1.4	21.6 ± 2.6
G	290.6 ± 72.6	973.6 ± 3.4	317.3 ± 5.3	96.0 ± 0.0	8.6 ± 0.5	683.0 ± 8.0	26.6 ± 1.9
H	289.0 ± 72.0	970.0 ± 11.3	316.6 ± 20.1	96.0 ± 0.8	9.0 ± 0.8	681.0 ± 5.7	28.0 ± 3.7
I	294.3 ± 71.4	981.6 ± 16.1	323.3 ± 19.2	96.0 ± 0.8	9.0 ± 1.6	687.3 ± 1.2	30.0 ± 6.2
J	284.3 ± 71.1	968.6 ± 5.2	304.6 ± 7.0	97.0 ± 0.0	7.0 ± 0.0	685.0 ± 1.4	21.3 ± 1.2
K	280.6 ± 72.3	970.0 ± 8.6	303.0 ± 7.1	96.6 ± 0.9	7.3 ± 0.9	689.6 ± 6.1	22.3 ± 4.5
L	281.6 ± 72.5	965.3 ± 7.6	305.0 ± 2.2	97.0 ± 0.0	8.0 ± 0.0	684.0 ± 5.7	23.3 ± 0.5

Table 8

Weight changes in eight towel subunits originally containing 48 fluid ounces of vegetable oil.

Wash Condition	Clean Unit Weight (g)	Oily Unit Weight (g)	Final Unit Weight (g)	Percentage of Oil Removed	Percent Residual Oil	Weight of Loaded Oil (g)	Weight of Residual Oil (g)
A	548.3 ± 62.0	1944.6 ± 14.8	631.0 ± 13.6	94.3 ± 2.4	12.6 ± 5.2	1396.3 ± 32.3	82.3 ± 34.4
B	571.6 ± 73.1	1958.0 ± 19.6	636.6 ± 33.6	95.3 ± 0.9	10.3 ± 1.2	1386.3 ± 11.1	65.3 ± 13.0
C	558.3 ± 73.8	1931.3 ± 18.0	617.3 ± 11.3	95.6 ± 0.5	9.6 ± 0.5	1372.3 ± 7.8	58.6 ± 3.7
D	556.3 ± 73.2	1928.0 ± 7.0	614.6 ± 11.0	95.6 ± 0.5	9.6 ± 0.9	1371.3 ± 7.5	58.0 ± 7.8
E	572.3 ± 73.2	1943.0 ± 21.9	619.6 ± 21.6	96.6 ± 0.5	7.6 ± 0.9	1371.0 ± 7.8	47.3 ± 6.3
F	566.6 ± 73.3	1947.0 ± 25.2	614.0 ± 23.3	96.6 ± 0.5	7.6 ± 0.5	1380.3 ± 6.2	47.3 ± 4.5
G	570.0 ± 73.7	1948.6 ± 8.4	644.3 ± 5.4	94.6 ± 0.5	11.6 ± 1.2	1379.0 ± 4.5	74.9 ± 7.8
H	541.0 ± 73.4	1957.3 ± 21.1	632.6 ± 5.3	93.6 ± 1.9	14.6 ± 5.2	1416.6 ± 53.5	91.6 ± 33.1
I	582.0 ± 73.9	1949.6 ± 15.1	641.0 ± 16.5	96.0 ± 0.0	9.3 ± 0.5	1368.0 ± 0.0	59.0 ± 2.2
J	574.6 ± 74.1	1928.6 ± 5.4	612.3 ± 3.9	97.3 ± 1.2	6.0 ± 2.2	1354.3 ± 19.5	37.6 ± 13.8
K	563.3 ± 73.8	1930.6 ± 3.9	609.6 ± 3.7	96.3 ± 0.5	7.6 ± 0.5	1367.3 ± 2.6	46.6 ± 4.8
L	568.0 ± 73.7	1931.3 ± 5.9	615.0 ± 2.9	96.6 ± 0.5	8.0 ± 0.0	1363.3 ± 5.7	47.3 ± 1.2

Table 9

Average weight of individual towels without added oil.

Wash Condition	Clean Towel Weight (g)	Final Towel Weight (g)	Weight Change	Percent Weight Change
A	70.3 ± 0.2	70.6 ± 0.3	0.3 ± 0.2	0.4 ± 0.3
B	70.5 ± 0.2	70.1 ± 1.0	-0.4 ± 1.1	-0.6 ± 1.5
C	69.7 ± 0.4	74.4 ± 10.4	4.7 ± 10.4	4.9 ± 10.7
D	70.3 ± 0.8	70.8 ± 1.4	0.4 ± 0.1	0.6 ± 0.1
E	70.6 ± 0.8	70.5 ± 1.4	-0.1 ± 1.8	-0.2 ± 2.8
F	72.9 ± 1.4	72.1 ± 1.5	-0.8 ± 1.9	-1.1 ± 2.7
G	71.8 ± 0.1	72.8 ± 0.2	1.0 ± 0.2	1.3 ± 0.2
H	70.5 ± 0.7	70.9 ± 0.1	0.4 ± 0.2	0.6 ± 0.3
I	74.7 ± 2.0	73.9 ± 1.4	-0.7 ± 0.2	-1.0 ± 0.2
J	73.2 ± 1.8	73.7 ± 1.3	0.4 ± 0.2	0.6 ± 0.1
K	71.4 ± 1.7	72.3 ± 1.0	0.8 ± 0.1	1.1 ± 0.1
L	72.6 ± 1.7	72.5 ± 1.3	-0.1 ± 0.1	-0.1 ± 0.2

Table 10

Weight changes in individual towels originally containing 24 fluid ounces of vegetable oil.

Wash Condition	Clean Towel Weight (g)	Oily Towel Weight (g)	Final Towel Weight (g)	Percentage of Oil Removed	Percent Residual Oil	Weight of Loaded Oil (g)	Weight of Residual Oil (g)
A	71.4 ± 0.7	241.6 ± 12.9	76.3 ± 1.7	97.0 ± 1.2	6.3 ± 2.5	170.2 ± 13.0	4.9 ± 1.9
B	72.1 ± 1.4	241.4 ± 14.0	78.3 ± 1.6	96.2 ± 0.4	7.9 ± 0.9	169.2 ± 13.0	6.2 ± 0.7
C	70.4 ± 1.4	242.1 ± 10.8	76.5 ± 0.6	96.4 ± 0.3	7.9 ± 0.6	171.7 ± 10.8	6.1 ± 0.4
D	71.3 ± 1.4	240.9 ± 4.5	76.1 ± 1.9	97.1 ± 0.4	6.2 ± 0.9	169.6 ± 4.3	4.7 ± 0.8
E	69.9 ± 1.4	240.1 ± 5.6	75.0 ± 1.4	97.0 ± 0.6	6.7 ± 1.3	170.2 ± 5.6	5.0 ± 1.1
F	70.1 ± 1.3	240.2 ± 2.3	75.6 ± 0.8	96.8 ± 0.3	7.2 ± 0.5	170.1 ± 2.3	5.5 ± 0.5
G	72.6 ± 1.7	243.4 ± 6.8	79.2 ± 1.3	96.1 ± 0.2	8.3 ± 0.7	170.7 ± 7.0	6.6 ± 0.5
H	72.2 ± 3.2	242.3 ± 6.4	79.2 ± 5.0	95.8 ± 0.6	8.8 ± 0.8	170.1 ± 5.9	7.0 ± 1.0
I	73.4 ± 3.5	245.3 ± 5.8	81.1 ± 5.0	95.5 ± 1.1	9.4 ± 2.1	171.8 ± 4.2	7.6 ± 1.9
J	71.0 ± 3.3	242.1 ± 7.7	75.9 ± 2.2	97.0 ± 0.5	6.5 ± 1.2	171.1 ± 7.5	4.9 ± 1.0
K	70.1 ± 3.2	242.5 ± 8.2	75.6 ± 2.6	96.8 ± 0.6	7.2 ± 1.2	172.4 ± 8.2	5.5 ± 1.1
L	70.3 ± 2.9	241.3 ± 3.7	76.1 ± 0.7	96.6 ± 0.2	7.6 ± 0.6	171.0 ± 3.7	5.8 ± 0.5

Table 11

Weight changes in individual towels originally containing 48 fluid ounces of vegetable oil.

Wash Condition	Clean Towel Weight (g)	Oily Towel Weight (g)	Final Towel Weight (g)	Percentage of Oil Removed	Percent Residual Oil	Weight of Loaded Oil (g)	Weight of Residual Oil (g)
A	69.7 ± 1.1	240.5 ± 6.9	77.0 ± 1.4	95.7 ± 0.2	9.4 ± 0.4	170.7 ± 6.8	7.2 ± 0.4
B	71.4 ± 2.6	244.7 ± 11.2	79.4 ± 4.3	95.3 ± 1.0	9.9 ± 1.6	173.2 ± 11.1	8.0 ± 1.7
C	69.8 ± 2.6	241.3 ± 11.8	77.1 ± 2.3	95.7 ± 0.9	9.4 ± 1.9	171.5 ± 11.0	7.3 ± 1.5
D	69.5 ± 2.2	240.9 ± 8.4	76.7 ± 1.6	95.7 ± 0.9	9.3 ± 1.3	171.4 ± 8.3	7.2 ± 1.2
E	71.5 ± 2.4	242.8 ± 8.5	77.2 ± 3.2	96.6 ± 0.7	7.4 ± 1.5	171.3 ± 7.7	5.7 ± 1.2
F	70.8 ± 2.4	243.3 ± 6.8	76.7 ± 3.2	96.5 ± 0.4	7.7 ± 0.5	172.5 ± 6.0	5.9 ± 0.6
G	71.2 ± 2.0	243.5 ± 8.5	80.5 ± 2.2	94.5 ± 0.6	11.5 ± 1.1	172.3 ± 8.3	9.2 ± 0.9
H	70.5 ± 1.7	242.2 ± 10.1	79.1 ± 1.4	95.0 ± 0.5	10.7 ± 0.8	171.7 ± 10.2	8.5 ± 0.7
I	72.7 ± 2.2	243.7 ± 8.3	80.6 ± 2.5	95.4 ± 0.4	9.7 ± 0.7	170.9 ± 8.1	7.8 ± 0.5
J	70.6 ± 2.0	241.0 ± 6.5	76.4 ± 0.9	96.5 ± 0.3	7.5 ± 0.6	170.4 ± 6.3	5.7 ± 0.5
K	70.4 ± 1.9	241.0 ± 8.2	76.2 ± 1.3	96.6 ± 0.4	7.6 ± 0.8	170.6 ± 8.4	5.7 ± 0.6
L	71.0 ± 1.7	241.4 ± 8.7	76.9 ± 0.7	96.5 ± 0.2	7.6 ± 0.3	170.4 ± 8.5	5.8 ± 0.3

Table 12

Peroxide values for oil samples - each value is the result of a single test
(milli-equivalents of peroxide/1000 grams sample)

	Unmodified	After Cold Petroleum Ether Extraction	After Hot Petroleum Ether Extraction
Stored Opened oil	70.17 71.64	73.35 75.61	- -
Stored Unopened	14.83 13.96	13.96 12.52	- -
New P&G Soybean oil	2.30 2.19	1.49 1.70	- -
USP Soybean oil	15.25 15.15	- -	15.50 15.37
Oil extracted from powder Detergent washed towels			*
Oil extracted from liquid Detergent washed towels			947.7 988.1

*Due to apparent interferences, values not obtained.

Table 13

Mackey test results for stored opened oil

Trial I		Trial II	
Starting Chamber Temp: 208° F		Starting Chamber Temp: 208° F	
Starting Time	Temperature (°F)	Starting Time	Temperature (°F)
0	116	0	104
0.5 hours	180	0.5 hours	191
1.0 hours	200	1.0 hours	203
1.5 hours	207	1.5 hours	207
2.0 hours	208	2.0 hours	208
2.5 hours	208	2.5 hours	208
3.0 hours	209	3.0 hours	208
3.5 hours	209	3.5 hours	208
4.0 hours	210	4.0 hours	209
4.5 hours	210	4.5 hours	209
5.0 hours	212	5.0 hours	209
5.5 hours	214	5.5 hours	210
		6.0 hours	212
		6.5 hours	215
		7.0 hours	220

6° rise over ambient

12° rise over ambient

Table 14

Mackey test results for stored unopened container

Trial I		Trial II		Trial III	
Chamber Temp: 208° F		Chamber Temp: 209° F		Chamber Temp: 209° F	
Starting Time	Temp. (°F)	Starting Time	Temp. (°F)	Starting Time	Temp. (°F)
0	112	0	115	0	100
0.5 hours	186	0.5 hours	178	0.5 hours	184
1.0 hours	202	1.0 hours	198	1.0 hours	200
1.5 hours	207	1.5 hours	204	1.5 hours	206
2.0 hours	208	2.0 hours	204	2.0 hours	208
2.5 hours	208	2.5 hours	206	2.5 hours	208
3.0 hours	209	3.0 hours	206	3.0 hours	208
3.5 hours	209	3.5 hours	206	3.5 hours	209
4.0 hours	209	4.0 hours	207	4.0 hours	210
4.5 hours	210	4.5 hours	207	4.5 hours	210
5.0 hours	210			5.0 hours	210
				5.5 hours	210
				6.0 hours	210
				6.5 hours	211
				7.0 hours	211

2° rise over ambient No rise over ambient 2° rise over ambient

Table 15

Mackey test results for new P&G soybean oil, 100%

Trial I		Trial II		Trial III	
Chamber Temp: 209° F		Chamber Temp: 206° F		Chamber Temp: 208° F	
Starting Time	Temp. (°F)	Starting Time	Temp. (°F)	Starting Time	Temp. (°F)
0	106	0	106	0	120
0.5	180	0.5	192	0.5	198
1.0	200	1.0	203	1.0	207
1.5	204	1.5	206	1.5	208
2.0	205	2.0	207	2.0	208
2.5	206	2.5	208	2.5	208
3.0	206	3.0	208	3.0	208
3.5	206	3.5	208	3.5	208
4.0	206	4.0	208	4.0	209
4.5	208	4.5	208	4.5	209
5.0	209	5.0	208	5.0	209
5.5	210	5.5	208	5.5	209
6.0				6.0	209
				6.5	210
				7.0	210

1° rise over ambient 2° rise over ambient 2° rise over ambient

Table 16

Mackey test results for towels loaded with oil and washed with liquid detergent

Trial I		Trial II	
Starting Chamber Temp: 208° F		Starting Chamber Temp: 206° F	
Starting Time	Temperature (°F)	Starting Time	Temperature (°F)
0	124	0	130
0.5 hours	188	0.5 hours	181
1.0 hours	202	1.0 hours	200
1.5 hours	206	1.5 hours	206
2.0 hours	208	2.0 hours	208
2.5 hours	212	2.5 hours	211
3.0 hours	214	3.0 hours	214
3.5 hours	212	3.5 hours	214
4.0 hours	210	4.0 hours	212
4.5 hours	210	4.5 hours	210
5.0 hours	209	5.0 hours	210
5.5 hours	208	5.5 hours	208
6.0 hours	208	6.0 hours	208

6° rise over ambient

8° rise over ambient

Table 17

Mackey test results for towels loaded with oil and washed with powder detergent

Trial I		Trial II	
Starting Chamber Temp: 206° F		Starting Chamber Temp: 206° F	
Starting Time	Temperature	Starting Time	Temperature
0	118	0	120
0.5 hours	176	0.5 hours	192
1.0 hours	198	1.0 hours	204
1.5 hours	204	1.5 hours	208
2.0 hours	208	2.0 hours	209
2.5 hours	209	2.5 hours	214
3.0 hours	215	3.0 hours	215
3.5 hours	220	3.5 hours	213
4.0 hours	216	4.0 hours	212
4.5 hours	212	4.5 hours	210
5.0 hours	211	5.0 hours	208

14° rise over ambient

9° rise over ambient

United States Testing Company, Inc.
1415 PARK AVENUE • HOBOKEN, NEW JERSEY 07030 • 201-792-2400 • Fax: 201-656-0636

REPORT OF TEST

January 27, 1994

CLIENT: Soap & Detergent Association
475 Park Avenue South
New York, NY 10016

PROJECT NO: 058848
FINAL REPORT
REVISED: 06/09/94

Attention: Dr. David Neun

SUBJECT:

Sample of 100% refined Soybean Oil received from Proctor & Gamble on September 8, 1993. Also tested was retained opened and unopened previously submitted, tested and stored Soybean Oil. Additionally a fresh sample of USP Grade Soybean Oil was purchased by U.S. Testing Company for testing.

AUTHORIZATION:

Client's Fax dated August 23, 1993.

PURPOSE:

The purpose of the test program was two fold. An examination and evaluation of the new and stored oil (A) with respect to the peroxide value (an indication of oil oxidation) and (B) self heating potential via a Mackey Test and to evaluate the self heating potential of towels (A) treated with the oil and (B) after treatment, washing and air drying via the Mackey Test.

TEST DATES:

October 19, 1993 to January 25, 1994.

PREPARED BY	SIGNED FOR THE COMPANY BY
Bernardita Santos Laboratory Supervisor	Joseph Kwiatkowski Assistant Vice President

SGS Member of the SGS Group (Société Générale de Surveillance)

• Biology • Chemistry • Environmental • Materials • Facilities in Principal Cities •

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PROCEDURES:

The test program was conducted in various steps.

I. The different oils were evaluated, as received or as purchased, for Peroxide value in accordance with the American Oil Chemists Society (AOCS) Method CD 8-53.

The stored oils (opened container and unopened container), and the new P&G oil were then extracted with petroleum ether (cold). The ether was then evaporated and the oil residue again evaluated for peroxide value to see if extraction with the ether would affect the oil.

The sample of USP Soybean oil was heated at reflux temperature with petroleum ether for six hours after which the ether was evaporated. The residue oil was analyzed for peroxide value to determine what affect, if any, a hot extraction would have on the oil. This was performed to establish a baseline for the latter extractions conducted on oil soaked, washed and dried towels.

II. The P&G New Soybean Oil and the two stored oils were also evaluated for their potential for spontaneous heating via the Mackey Test per Federal Test Method Standard 191A Method 5920 (Modified). This test monitors the temperature of the test sample while being subjected to a relatively constant temperature in a chamber surrounded by steam. A rise of the sample temperature above the ambient starting chamber temperature is normally considered indication of the potential for spontaneous heating.

III. In an effort to determine the effect of washing on towels containing the oil the following evaluations were also conducted:

- Three hand towels were cut in half. Approximately 71 grams of oil were added to each piece of towel, after which three pieces of towels were placed into each of two clean loads of ballast towels.
- An additional 220 grams of oil was added (110 grams each) to two whole towels. One of which was added to each of the ballart loads.
- Both loads were allowed to set for 30 minutes prior to washing.

United States Testing Company, Inc.

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RESULTS:

I. Peroxide value, of the various oils in milli-equivalents of peroxide/1000 grams of sample.

	As Is	After Cold Petroleum Ether Extraction	After Hot Petroleum Ether Extraction
Stored	70.17	73.35	-
Opened Oil	71.64	75.61	-
Stored	14.83	13.96	-
Unopened Oil	13.96	12.52	-
New P&G	2.30	1.49	-
Soybean Oil	2.19	1.70	-
USP	15.25	-	15.50
Soybean Oil	15.15	-	15.37

By definition (AOCS) the peroxide value "method determines all substances, in terms of milli-equivalents of peroxide per 1000 grams of sample, which oxidize potassium iodide under the conditions of the test. These are generally to be peroxides or other similar products of fat oxidation".

The value increases as the oil is oxidized.

II. Peroxide value of oils extracted from washed towels in milli equivalents of peroxide/1000 grams of sample.

	Trial 1	Trial 2
Oil Extracted From Powder Detergent Washed Towels	*	*
Oil Extracted From Liquid Detergent Washed Towels	947.7	988.1

*Due to apparent interferences, value not obtained.

PROCEDURES (CONT'D):

The loads were washed as follows:

Wash #1 - Warm water (100°F)
Load - 165 ppm water hardness as calcium carbonate
6 lb. wash load
Powder detergent, 97 grams/load (previously submitted by SDA)

Wash #2 - Warm water (100°F)
Load - 165 ppm water hardness as calcium carbonate
6 lb. wash load
Liquid detergent, 124 grams/load (previously submitted by SDA)

After washing, both loads were air dried.

Following the drying, two sections from the half towels of each of the wash loads were subjected to the Mackey Test.

The remaining half and full size oil treated towels were subjected to soxhlet extraction with petroleum ether to remove any residual soybean oil.

After extraction and evaporation of the residual ether, the residue (oil) was analyzed for peroxide value, to determine what effect if any the detergent-washing and drying might have on the oils.

United States Testing Company, Inc.

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III. Mackey Test

Stored Opened Oil

Trial I		Trial II	
Starting Chamber Temp: 208°F		Starting Chamber Temp: 208°F	
Starting Time	Temperature	Starting Time	Temperature
0	116°	0	104°
.5 hours	180°	.5 hours	191°
1.0 hours	200°	1.0 hours	203°
1.5 hours	207°	1.5 hours	207°
2.0 hours	208°	2.0 hours	208°
2.5 hours	208°	2.5 hours	208°
3.0 hours	209°	3.0 hours	208°
3.5 hours	209°	3.5 hours	208°
4.0 hours	210°	4.0 hours	209°
4.5 hours	210°	4.5 hours	209°
5.0 hours	212°	5.0 hours	209°
5.5 hours	214°	5.5 hours	210°
		6.0 hours	212°
		6.5 hours	215°
		7.0 hours	220°

6° rise over ambient

12° rise over ambient

United States Testing Company, Inc.

CLIENT: Soap & Detergent Association

PROJECT NO: 058848
DATE: 01/27/94
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Stored Unopened Container

Trial I		Trial II		Trail III	
Chamber Temp: 208°F		Chamber Temp: 209°F		Chamber Temp: 209°F	
Starting Time	Temp.	Starting Time	Temp.	Starting Time	Temp.
0	112°	0	115°	0	100°
0.5 hours	186°	0.5 hours	178°	0.5 hours	184°
1.0 hours	202°	1.0 hours	198°	1.0 hours	200°
1.5 hours	207°	1.5 hours	204°	1.5 hours	206°
2.0 hours	208°	2.0 hours	204°	2.0 hours	208°
2.5 hours	208°	2.5 hours	206°	2.5 hours	208°
3.0 hours	209°	3.0 hours	206°	3.0 hours	208°
3.5 hours	209°	3.5 hours	206°	3.5 hours	209°
4.0 hours	209°	4.0 hours	207°	4.0 hours	210°
4.5 hours	210°	4.5 hours	207°	4.5 hours	210°
5.0 hours	210°			5.0 hours	210°
				5.5 hours	210°
				6.0 hours	210°
				6.5 hours	211°
				7.0 hours	211°

2° rise over ambient No rise over ambient 2° rise over ambient

United States Testing Company, Inc.

CLIENT: Soap & Detergent Association

PROJECT NO: 058848
DATE: 01/27/94
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REVISED: 06/09/94

Towels Loaded With Oil And Washed With Liquid Detergent

Trial I		Trial II	
Starting Chamber Temp: 208°F		Starting Chamber Temp: 206°F	
Starting Time	Temperature	Starting Time	Temperature
0	124°	0	130°
0.5 hours	188°	0.5 hours	181°
1.0 hours	202°	1.0 hours	200°
1.5 hours	206°	1.5 hours	206°
2.0 hours	208°	2.0 hours	208°
2.5 hours	212°	2.5 hours	211°
3.0 hours	214°	3.0 hours	214°
3.5 hours	212°	3.5 hours	214°
4.0 hours	210°	4.0 hours	212°
4.5 hours	210°	4.5 hours	210°
5.0 hours	209°	5.0 hours	210°
5.5 hours	208°	5.5 hours	208°
6.0 hours	208°	6.0 hours	208°

6° rise over ambient

8° rise over ambient

United States Testing Company, Inc.

CLIENT: Soap & Detergent Association

PROJECT NO: 058848
DATE: 01/27/94
FINAL REPORT
REVISED: 06/09/94

New P&G Soybean Oil, 100%

Trial I		Trial II		Trail III	
Chamber Temp: 209°F		Chamber Temp: 206°F		Chamber Temp: 208°F	
Starting Time	Temp.	Starting Time	Temp.	Starting Time	Temp.
0	106°	0	106°	0	120°
0.5	180°	0.5	192°	0.5	198°
1.0	200°	1.0	203°	1.0	207°
1.5	204°	1.5	206°	1.5	208°
2.0	205°	2.0	207°	2.0	208°
2.5	205°	2.5	208°	2.5	208°
3.0	206°	3.0	208°	3.0	208°
3.5	206°	3.5	208°	3.5	208°
4.0	206°	4.0	208°	4.0	209°
4.5	206°	4.5	208°	4.5	209°
5.0	208°	5.0	208°	5.0	209°
5.5	209°	5.5	208°	5.5	209°
6.0	210°			6.0	209°
				6.5	210°
				7.0	210°

1° rise over ambient 2° rise over ambient 2° rise over ambient

United States Testing Company, Inc.

CLIENT: Soap & Detergent Association

PROJECT NO: 058848
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REVISED: 06/09/94

Towels Loaded With Oil And Washed With Powered Detergent

Trial I		Trial II	
Starting Chamber Temp: 206°F		Starting Chamber Temp: 206°F	
Starting Time	Temperature	Starting Time	Temperature
0	118°	0	120°
0.5 hours	176°	0.5 hours	192°
1.0 hours	198°	1.0 hours	204°
1.5 hours	204°	1.5 hours	208°
2.0 hours	208°	2.0 hours	209°
2.5 hours	209°	2.5 hours	214°
3.0 hours	215°	3.0 hours	215°
3.5 hours	220°	3.5 hours	213°
4.0 hours	216°	4.0 hours	212°
4.5 hours	212°	4.5 hours	210°
5.0 hours	211°	5.0 hours	208°

14° rise over ambient

9° rise over ambient

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DATE: 01/27/94
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CONCLUSIONS & COMMENTS:

As indicated in the results, neither cold nor hot petroleum ether extractions appear to cause any marked or increase in the peroxide values of the oils. However, a noticeable difference is seen in the old stored oil versus the new.

Most notable however, is the apparent peroxide values of the oil extracted from the washed towel. Considerable oxidation appears to have occurred.

The results of the Mackey Tests are also indication of apparent significant temperature rises in the towels which were oil loaded, washed and dried.

Further study would be required to determine statistically the validity of the results, and the effects of various loading and/or wash conditions.