Part II —

Clothes dryer lint:

Testing reaffirms spontaneous heating of lint is unlikely

by Jack L. Sanderson, Editor

Last issue, *Fire Findings* presented results of tests to determine the potential for spontaneous combustion of lint in residential dryers.

We tested various types and amounts of lint by heating it and monitoring its temperature, but none of the lint underwent spontaneous heating.

For this issue, we washed and dried vegetable oil-soaked towels to see how the oil in the load affected the lint that was created.

Spontaneous combustion of rags and towels that contain vegetable oils, even after laundering, is a well-established phenomenon. For this series of tests, however, we wanted to determine if the lint from oil-soaked laundry loads contained those same oils.

If so, was it likely the oil in the lint could cause spontaneous combustion leading to dryer fires?

Typical home oil spill depicted

We sought to simulate what might transpire for vegetable oil-soaked rags to need laundering. In our experience, household oil spills lead to this situation. Someone knocks over a container of cooking oil or upsets a deep fat fryer filled with oil. Out come the rags for cleaning up the mess.

To simulate such a scene, we bought new, white towels to use as our rags. We washed and dried them to get rid of the excess lint that accompanies the first laundering. Next, we "spilled" corn oil on a nonporous surface and used the towels to mop up the oil.

Each load of laundry consisted of the nine towels we used to soak up a total of 1 gallon of corn oil. We had divided the corn oil into nine equal parts so each towel absorbed an equal amount — about 14.2 ounces each.

We spread the oil as equally as possible across the towels and made every effort to distribute it evenly so samples submitted to MDE Forensic Laboratories for chemical testing had an equal amount of oil initially.

We then placed all the towels in the washer, added one-half cup of Tide detergent and set the washer on the hot-water setting for a "normal" wash cycle of about 35 minutes. (The actual agitation time in the wash cycle was about 10 minutes). The temperature of the water was 127 degrees Fahrenheit.

After the washer finished laundering the towels, we cleaned the lint filter in the dryer very carefully and placed the towels in the dryer for a 60-minute, timed cycle. The lint trapped from each load was preserved for testing.

We weighed the dried towels and the lint from the dryer load, then washed and dried the towels again, once more preserving the lint that resulted. We washed and dried all the towels three times after initially using them to sop up the spilled oil.

At each step in this process, we took a 3-inch square section of one of the towels from the load for testing. We also weighed every load at each step to get some idea of the amount of oil that remained in the towels. The lint, too, was weighed, preserved and tested for the presence of oil.

Weight of towels and lint after laundering

Material	Wt. of new towels before wash/drying	Wt. of towels after initial wash/drying	Wt. of towels after absorbing corn oil	Wt. of towels after first wash/drying	Wt. of lint from first drying	Wt. of towels after second wash/drying	Wt. of lint from second drying	Wt. of towels after third wash/drying	Wt. of lint from third drying
100% cotton towels, 59x32 Ave. wt. — 17.74 oz.	9.98 lbs.	9.80 lbs.	17.06 lbs.	12.64 lbs.	0.095 oz.	11.52 lbs.	0.100 oz.	10.26 lbs.	0.125 oz.
86% cotton 14% polyester towels, 48x26$^1/_2$ Ave. wt. — 18.74 oz.	10.54 lbs.	10.22 lbs.	17.54 lbs.	13.98 lbs.	0.035 oz.	12.64 lbs.	0.060 oz.	12.16 lbs.	0.085 oz.

Figure 1. Even without chemical analysis, the retention of oil in the towels seemed obvious from the weights of the dried towels. Although the weights decreased with each laundering, even after the third washing and drying the towels still weighed more than they did before we added the oil.

For this first series of tests, we used 59-inch by 32-inch 100-percent cotton towels. Then we repeated the tests using 48-inch by $26^1/_2$-inch towels made of 86 percent cotton and 14 percent polyester.

Plenty of oil still remained in the towels

Even without MDE's chemical analysis report, there was little doubt oil remained in the towels after the washing and drying process. For example, nine dry 100-percent cotton towels that weighed 9.8 pounds before soaking up more than 7 pounds of corn oil still weighed 12.6 pounds after we washed and dried them the first time *(Figure 1)*.

The first laundering removed more than half of the oil, but almost 3 pounds apparently remained — plenty of oil, in our estimation, for the towels to undergo spontaneous heating given the right conditions *(Figure 2)*.

Overall, more oil remained in the cotton-polyester blend towels than the cotton towels. After the third washing, the cotton blend towels apparently still contained almost 2 pounds of oil and the cotton towels contained less than one-half pound.

That difference may not be attributable to the different materials, however. Although the cotton towels were larger than the cotton-polyester blend towels (1,888 square inches compared to 1,272 square inches each), they were lighter than the blend towels.

From the start, the cotton blend towels were thicker and fluffier than their counterparts. They were probably more absorbent as well, which may account for them retaining more oil than the cotton towels.

One engineer from an appliance manufacturing company told us their testing shows about 50 percent of oil is removed from materials with each washing. Our tests showed much the same: The cotton towels generally lost a little more than 50 percent of the oil with each washing while the cotton blend towels lost a little less than 50 percent.

Apparent weight/percent of oil in towels after laundering

Material	Wt. of oil added to towels before washing	Wt. of remaining oil after first washing/drying	Wt. of remaining oil after second washing/drying	Wt. of remaining oil after third washing/drying
100% cotton towels	7.26 lbs.	2.84 lbs.	1.72 lbs.	0.46 lbs.
app. % wt. of oil in towels	43	23	15	4
86% cotton 14% polyester towels	7.32 lbs.	3.76 lbs.	2.42 lbs.	1.94 lbs.
app. % wt. of oil in towels	42	27	19	16

Figure 2. This chart shows the apparent amount of oil remaining in the towels through three launderings. We determined the apparent percentage weights of the oil remaining in the towels by weighing all the towels. When MDE chemist, Dale Mann, performed his tests, he extracted all the oil from 3-inch samples of the towels. With one exception, the percentages Fire Findings obtained are quite similar to those Mann obtained from chemical testing. The 4-percent figure you see above in column 5 is quite a bit less than the 18-percent figure he derived in column 5 of Figure 4 (page 14). The two percentages may be different because the sample may not have contained the same percentage of oil as the rest of the towel. Perhaps the portion of the towel where the sample was taken absorbed more oil than the rest of the towel.

Amount of oil in lint not enough to start the heating process

One load of 100-percent cotton towels produced less than one-tenth ounce (.095) of lint, and the cotton-polyester towels produced even less (0.035 ounces of lint).

If the percentage of oil (by weight) in the lint were the same as the percentage in the all-cotton towels themselves, less than .05 ounce of oil would be available to initiate the spontaneous heating process. Based on previous *Fire Findings*' tests, this amount is far less than needed for spontaneous heating to occur.

Figure 3. The lint we recovered from the oil-soaked towels appeared much the same as the uncontaminated towels, with one exception. Clusters of very small lint balls attached themselves to the contaminated lint.

The lint from the oil-soaked towels looked different than the lint from the uncontaminated towels. Nearly all of the lint from the uncontaminated towels was light and fluffy, what you normally see in a dryer lint trap. The lint from the contaminated loads was covered with small nodules of lint *(Figure 3)*. It appeared the residual oil may have "glued" the pieces of lint together.

Clustering such as this might create better conditions for spontaneous combustion if the balls that resulted were large enough; however, the individual balls produced during these tests were all less than one-fourth inch in diameter, probably too small to contribute to the self-heating process.

(Continued on page 14.)

(Continued from page 13.)

Dryer lint testing ...

In discussing lint with the laundry appliance engineer, we learned lint is created by the stretching, pulling and breaking of minute fibers in fabrics. The process begins during washing and continues as materials dry in the dryer.

Some materials produce more lint than others do, he said. Our tests showed, for example, that the 100-percent cotton towels produced two to three times more lint than the cotton-polyester blend towels.

Spontaneous combustion of lint seems a very unlikely event

After conducting the oil-soaked towel tests, it appears spontaneous combustion of residual oil in the lint is an unlikely cause of dryer fires. There just isn't enough material to support an ongoing chemical reaction.

In fact, we placed the lint from the oil-soaked towels in other dryer lint and tried heating it, but the results were the same from previous tests: Not a hint of spontaneous heating occurred.

It is possible, however, to envision a very rare scenario when the spontaneous combustion of lint might start a dryer fire. If laundered loads of vegetable oil-soaked materials are frequently placed in a dryer, a sizable quantity of oil-soaked lint might accumulate in the dryer's vent path.

In that situation and given ideal conditions, spontaneous combustion might be possible. However, it's our opinion that spontaneous combustion of lint would be a most unusual event requiring unique circumstances.

For investigators who suspect a dryer caused a fire, it's important to ask users what they routinely dried in the machine and what were the contents of the last load dried in it.

Also, see what was dried in many loads before the last one with an eye toward establishing a pattern of loads containing materials subject to spontaneous combustion.

Percent weight of oil chemically extracted from samples

Material	% wt. of oil in towels after absorbing oil	% wt. of oil after first washing/drying	% wt. of oil after second washing/drying	% wt. of oil after third washing/drying
100% cotton towels	43	29	21	18
100% cotton lint		26	20	16
86% cotton 14% polyester towels	42	28	19	16
86% cotton 14% polyester lint		27	16	8

Figure 4. Numbers are the percent of weight of corn oil in the analyzed samples; i.e., corn oil equal to 43 percent of the weight of the 100-percent cotton towels was added before the first washing. After the third laundering, the samples still contained 18 percent oil by weight.

Percentages of oil in lint mirrored those of the towels

So what did the lab results indicate? According to Dale C. Mann, a forensic chemist with MDE Forensic Laboratories, corn oil was recovered from the samples of both the 100-percent cotton towels and the cotton blend towels.

In addition, he identified corn oil in every lint sample gathered during our towel launderings.

By completely extracting all the oil from the samples, he was able to determine the percentage of oil remaining in the samples by weight *(Figure 4)*. Mann said the amounts of oil in the lint (as a percentage of weight) were similar to the amounts of oil in the towels that produced the lint.

Infrared (IR) spectroscopy identified the oil very efficiently, he added, but gas chromatography/mass spectrometry (GC/MS) methods were not as useful because the higher molecular weight of the recovered oil made chromatography of the oils more difficult.

Since chemists primarily use GC/MS to analyze fire debris, it's important fire investigators tell their chemists about any products in particular that need to be identified.

For example, a chemist attempting to identify accelerant residue might not discover vegetable oils involved in a spontaneous combustion situation because equipment other than a GC/MS spectrometer is better suited for that type of testing.

Editor's note: MDE, originally known as Machine Design Engineers, has grown into a multi-discipline professional engineering firm that encompasses a new, fully-equipped forensic laboratory operation.

Mann recently joined MDE after 18 years with the Washington State Patrol Crime Laboratory. During his last nine years there, he supervised the Chemistry and Microanalysis sections of the Tacoma Crime Laboratory.

For more information, call Mann at (206) 622-2007; fax (206) 622-2248; write 700 South Industrial Way, Seattle, Washington 98108-5231 or visit MDE's Web site at **www.mde.com**. FF