T.A.G.
RESOURCE RECOVERY

FAX COVER PAGE

Date: 12/8/93

From: Terry Gray
TAG Resource Recovery
(713) 463-7552

To: Joe Kohn

Pages (including cover page): 16

Message: Joe, attached is our analysis and documentation draft of Florida Tire's density tests. Your comments and suggestions are welcome. Thanks,

Terry

18036 RADWORTHY DRIVE * SUITE 110 * HOUSTON, TX 77084 PHONE: (713) 463-7552

DRAFT

11/29/93

ANALYSIS OF
WHOLE AND SHREDDED WASTE TIRE DENSITY TESTS
CONDUCTED BY
FLORIDA TIRE RECYCLING, INC

Prepared for

The Florida Department of Environmental Protection

by

Terry A. Gray

TAG Resource Recovery

November, 1993

THIS IS AN ENFORCEMENT DOCUMENT SPECIFICALLY REQUESTED BY JANET BOWMAN, ESQ. AND IS CONSIDERED A CONFIDENTIAL DOCUMENT IN ENFORCEMENT PROCEEDINGS UNLESS RELEASED BY THE FLORIDA DEPARTMENT OF ENVIRONMENTAL REGULATION

Florida Tire Recycling, Inc
Density Test Results
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OBJECTIVE

A series of on-site tests were conducted by Florida Tire Recycling, Inc. on November 2, 1993 to define the density of waste tires and shreds. The tests were structured and implemented by Mr. Joe Friscia, a consulting engineer engaged by Florida Tire. At the request of Florida Tire, the tests were observed by Mr. Joe Kahn, Mr. Joe Lurix, and Mr. Manny Delosantos of DEP's West Palm Beach Office and Mr. Terry Gray, President of T.A.G. Resource Recovery (a technical waste tire consulting firm under contract to DEP). This analysis summarizes test observations and results as requested by Ms. Janet Bowman of DEP.

TEST RESULTS

The methodology, detailed calculations, and comments associated with each of these tests are contained in Appendix A, organized according to the type of tire or shred examined. Exhibit 1 provides a comparison of these test results with corresponding densities used by T.A.G. Resource Recovery (TAG) in its on-site quantity estimates and other documents requested by Janet Bowman of DEP. Exhibit 2 summarizes the comparative impact of utilizing test results versus TAG estimates in determining on-site quantities and site storage capabilities. The following sections briefly summarize major points associated with testing procedures, comparative densities and abatement impact.

Whole Tires

Although Florida Tire appeared to be making a conscientious effort to develop meaningful data, their testing procedures for whole tires were not structured to obtain densities representative of actual on-site piles in spite of constructive suggestions made by Mr. Kahn and Mr. Gray. The stacked, laced and loose density tests were based on approximate measurement of small quantities of freshly-prepared, "randomly selected" incoming tires. However, since tire piles like those present at Florida Tire settle and compact with age, tests must measure actual in-place density to be considered representative of pile conditions. In addition, tire piles are often irregularly shaped, requiring approximation of average edge dimensions. Possible error margins associated with such approximations can represent a significant percentage of small pile measurements, but this percentage declines with measurement of larger pile surfaces. Tests conducted on small quantities of "randomly selected" tires are also not necessarily representative of average sizes received over a longer period of time or contained in the storage piles. These fundamental test flaws affect the applicability of the data to practical quantity estimates and abatement issues.

The average whole tire weights obtained in the tests were slightly higher than the industry average for truck tires and lower for passenger tires. Based on the estimated quantities in remaining piles as of November 2, 1993, use of test average weights would decrease passenger tire tonnage by 96 tons and increase truck tire tonnage by 234 tons, resulting in a net addition of 138 tons.

The laced and stacked density tests are not representative of actual pile conditions. In contrast to Florida Tire's test procedures, TAG developed its whole tire pile density estimates based on measuring and counting large sections of in-place tires, thereby including compaction impact and minimizing percentage errors associated with measurements. Since Florida Tire's tests did not define in-place density, the tests are not applicable and no estimate adjustment is appropriate. The loose pile test results have no impact on quantity estimates because loose piles of passenger and truck tires were not included in previous estimates and recently added loose piles are configured differently than the test piles.

In-Place Pile Density

The fundamental methodology used in Florida Tire's in-place shred density tests was based on suggestions made by TAG. Shreds were removed from two measured areas chosen by Florida Tire within pile segments directly adjacent to initial fire lanes. Shreds were placed in a truck (previously weighed empty) and weighed on the site scale. The first site was intended to represent finer shreds, although large shreds (some close to half tires) were observed. The second site was intended to represent coarse shreds typical of those contained within most of the pile. The net weight of the removed shreds in each test divided by the excavated volume yields shred density.

Unfortunately, difficulties were encountered in implementation of the tests due to Florida Tire's selection of excavation sites. In the first test, shreds were removed from a rectangular area at the junction of fire lanes rather than directly within the pile as suggested, so some shreds slid outside the area and were not captured and weighed. Small quantities of shreds fell from the loader bucket prior to dumping into the truck. It was also difficult to measure the excavated area. However, the tested density was approximately 41.2 pounds/cubic foot, only 1.2 pounds/cubic foot (3%) greater than TAG's estimated density of 40 pounds/cubic foot. Although it is not feasible to accurately estimate the portion of the pile containing similar shreds, use of the test density would increase on-site quantities by 150 tons for each 5,000 tons initially calculated by TAG.

In the second test, shreds were removed from a triangular area at the junction of fire lanes rather than directly within the pile due to loader accessibility, but shred capture appeared to be better than the first test. Small quantities of shreds still fell from the loader bucket prior to dumping into the truck. The excavated area dimensions were those provided to Mr. Kahn by Mr. Friscia, the consulting engineer engaged by Florida Tire to conduct the testing.

The selected area was estimated to have a density of 38 pounds/cubic foot in previous quantity calculations. The tested density is 59.5 pounds/cubic foot, or approximately 57%, greater than the estimated density. Use of this tested density would increase the calculated on-site quantity by almost 25,000 tons if 43,850 tons of the initially estimated 48,850 tons are considered to be similar shreds. However, the tested density is unusually high for a compacted pile of coarse shreds, indicating that there was either an error in Mr. Friscia's measurement or that the result was influenced by contamination within the shred pile. If the result is due to extensive contamination, then any ultimate transport and disposal costs that are based on weight will increase proportionately unless the contamination is removed prior to disposal.

Loose Shred Density

The apparent objective of these tests was to define the density that could be expected if the existing main shred pile were reconfigured into a series of shallow, uncompacted piles conforming to DEP rules. However, the tests utilized shreds taken directly from processing equipment rather than from the piles. Tests were conducted on finer (nominal 2 inch) shreds from the CM shredder and on coarse (one-pass) shreds from the SSS shredder (bypassing the recycling trommel). Shreds were loaded directly from the processing equipment into trucks, leveled by manual raking to predetermined side benchmarks, and then weighed. Truck bed dimensions were measured to allow volume calculation. Net shred weight divided by volume yields average density.

Although implementation of these tests involved fundamental flaws, the raw test result for coarse shreds was within approximately 8% of the densities used by TAG. If the raw results are adjusted to correct procedural flaws, the test result becomes identical to TAG's projection for uncontaminated coarse shreds. Since most shreds (estimated to be over 90%) on-site are coarse and the adjusted density differs by 0 - 8% from TAG's estimated 700 pounds/cubic yard, this test has little practical impact upon the maximum quantity that can be stored on-site.

SUMMARY

The density tests conducted by Florida Tire represented an effort on their part to define critical parameters required for determination of on-site storage quantities and stabilization plans. Although some tests contained procedural flaws that made them inapplicable to actual site conditions, the other applicable results confirmed estimates utilized by TAG (within reasonable margins) with one notable exception. The tested in-place density of coarse shreds was significantly greater than projected. This result may be due to a measurement error or to extensive shred contamination that was not determinable from previous surface observations of piles. If the result is actually due to contamination, it would proportionately increase the actual tonnage requiring removal from the site or require additional reprocessing (and expense) to separate contaminants. This test should be repeated at several appropriate pile locations prior to establishing a detailed budget for site abatement since it could have a significant economic impact.

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EXHIBIT 1

TEST RESULT SUMMARY AND COMPARISON

TYPE	UNITS	DENSITY		DIFFERENCE	
		TEST	TAG	AMOUNT	%
WHOLE PASSENGER TIRES					
Unit	lbs/tire	17.8	20.0	2.2	-11
Laced	tires/cu yd	12.4	13.0*	0.6	- 5
Loose	tires/cu yd	6.5	10.0	3.5	-35
WHOLE TRUCK TIRES					
Unit	lbs/tire	108	100	8	+ 8
Stacked	PTE/cu yd	13	18**	5	-28
Loose	PTE/cu yd	11	N/A	N/A	N/A
SHREDDED TIRES					
Loose/Nom. 2"	lbs/cu yd	797	750	47	+ 6
(adjusted)		718	750	32	- 4
Loose/Coarse	lbs/cu yd	756	700	56	+ 8
(adjusted)		700	700	0	0
Inplace/Mixed	lbs/cu ft	41.2	40	1.2	+ 3
	lbs/cu yd	1,112	1,080	32	+ 3
Inplace/Coarse	lbs/cu ft	59.5	38	21.5	+57
	lbs/cu yd	1,607	1,026	581	+57

* Density used for comparable shallow, newly laced passenger tires
** Based on in-place analysis of actual Florida Tire pile

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EXHIBIT 2

COMPARATIVE DENSITY IMPACT

TYPE	% DIFFERENCE	ESTIMATED QUANTITY (TONS) TAG	TEST	DIFFERENCE
WHOLE PASSENGER TIRES				
Unit	-11	870	774	- 96
Laced	- 5	870	N/A	N/A
WHOLE TRUCK TIRES				
Unit	+7.5	3,340	3,574	+ 234
Stacked	- 28	3,340	N/A	N/A
WHOLE OFF-ROAD TIRES				
Loose	--	2,940	2,940	--
SHREDDED TIRES				
Inplace/ Mixed	+ 3	~5,000	~5,150	+ 150
Inplace/ Coarse	+ 57	~43,850	~68,845	+24,995
TOTAL IMPACT				
TOTAL	+45	56,000*	81,283	+25,283
MAXIMUM ON-SITE STORAGE IMPACT				
Loose/ Coarse	+ 8	38,050	41,094	+3,044
Adjusted	0	38,050	38,040	0

* Assumes processed whole passenger tire piles were removed from site

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APPENDIX A

DETAILED TEST METHODOLOGY, DATA AND CALCULATIONS

WHOLE PASSENGER TIRES

Average Unit Weight

Methodology - "Randomly selected" passenger and light truck tires were placed on three carts, counted and weighed on the truck scale. The tires were unloaded and the empty carts were weighed. The net weight divided by the quantity yields an average weight per tire.

Calculations - Quantity of tires: 65 + 65 + 66 = 196 tires

Weight: gross - tare = net weight
4,120 lbs - 640 lbs = 3,480 lbs

Average Weight: 3,480 lbs/196 tires = 17.8 lbs/tire

Comments - The industry recognizes an average passenger tire equivalent (including light truck tires) as 20 pounds based on a typical balance between passenger tires (12-24 pounds each) and light truck tires (20-35 pounds each). Variations are to be expected from truckload to truckload based on the tire type generated at specific collection points. A limited test like this one conducted by Florida Tire is totally dependent on the mix of selected tires and is not necessarily representative of a long-term average. The selected tires were not taken from existing stockpiles, so they may not even reflect actual inventory.

Impact - Even if the average weight of passenger/light truck tires collected by Florida Tire is below average, it has little impact on quantity estimates. As of November 2, 1993, only 2 piles of passenger tires (T-5 and T-6) containing an estimated total of 87,000 passenger tires remained on-site. Using a weight of 17.8 pounds/passenger tire instead of 20 pounds would only decrease the on-site estimate by 96 tons or less than 0.2%.

Laced Density

Methodology - Tires contained in a single row of newly-received laced tires were counted, followed by measurement of approximate row dimensions to define volume. Quantity divided by volume yields tires/cubic yard.

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Calculations - Quantity: 210 tires (counted)

Volume: length X width X height = volume

35 ft X 2.27 ft X 5.9 ft = 456.8 cu ft
÷ 27 cu ft/cu yd = 16.9 cu yd

Density: 210 tires ÷ 16.9 cu yd = 12.4 tires/cu yd

Comments - TAG uses 13 passenger tires/cubic foot in its estimates of shallow newly-stacked passenger tires (comparable to test conditions), well within the measurement error margin of this limited test. Since tires compact with time, TAG applied a density of 15 passenger tires/cubic yard (representing 15% compaction) to the older settled piles present at Florida Tire based on analysis of compacted, laced piles.

Impact - Since this test confirmed the normal density estimate for freshly-laced shallow piles within the measuring error margin and did not define the in-place density of Florida Tire's settled piles as suggested, the test provides no basis for adjusting quantity estimates.

Loose Density

Methodology - The previously counted tires were tossed into an irregularly-shaped shallow pile, then approximate average dimensions were measured. Quantity divided by approximate volume yields approximate density.

Calculations - Quantity: 210 tires (counted)

Approx. Volume: 8.83' X 21.83' X 4.5' = 867.4 cu ft
÷ 27 cu ft/cu yd = 32.1 cu yd

Density: 210 tires ÷ 32.1 cu yd = 6.5 tires/cu yd

Comments - A typical density of 10 tires/cubic yard for loose, shallow passenger tire piles has been extensively demonstrated during actual abatement of sites. This test result simply illustrates the difficulty in attempting to approximate actual pile conditions through non-representative tests of small, irregularly-shaped piles.

Impact - This test has no impact on site abatement analysis since no piles containing loose passenger tires were included in previous quantity estimates.

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WHOLE MEDIUM TRUCK TIRES

Average Unit Weight

Methodology - "Randomly selected" truck tires were unloaded from a trailer, counted and weighed on the truck scale. The net weight divided by the quantity yields an average weight per tire.

Calculations - Quantity of tires: 48 tires (counted)

Weight: 5,160 lbs

Average Weight: 5,160 lbs/48 tires = 107.5 lbs/tire

Comments - The industry recognizes an average waste truck tire weight as 100 pounds. Variations are to be expected based on tire size and condition. Water splashed from some tires during handling, but residual water typically remains within these tires. Any limited test is not necessarily representative of a long-term average. The selected tires were not taken from existing stockpiles, so they may not even reflect actual inventory.

Impact - If the average weight of truck tires collected by Florida Tire is above average, it has limited impact on quantity estimates. The tonnage contained in 5 piles of truck tires previously estimated to contain 3,340 tons would increase by 7.5%, or 234 tons, representing less than 0.4% of the estimated on-site total.

Stacked Density

Methodology - The approximate dimensions of the two rows of newly-stacked truck tires prepared for the average weight test were measured to define volume. Quantity divided by volume yields tires/cubic yard.

Calculations - Quantity: 48 tires (counted)

Volume: length X width X height = volume

20.75 ft X 7.42 ft X 3.25 ft = 500.4 cu ft ÷ 27 cu ft/cu yd = 18.5 cu yd

Density: 48 tires ÷ 18.5 cu yd = 2.6 tires/cu yd X 5 = 13 PTE/cu yd

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Comments - These test conditions are not representative of the stacked storage piles at Florida Tire (which are over twice as deep and have compacted with time) and are vulnerable to significant percentage errors resulting from stack spacing and measurement uncertainties. TAG's estimate of 18 PTE/cubic yard was based on analysis of actual in-place pile density. The actual number of tires/stack and stacks/row in pile areas over 100 feet long were counted and measured, resulting in a density representative of actual pile conditions with a comparatively low margin of error.

Impact - Since this test did not define the in-place density of Florida Tire's settled piles as suggested, the test provides no basis for adjusting quantity estimates.

Loose Density

Methodology - The previously weighed tires were tossed into an irregularly-shaped shallow pile, then approximate average dimensions were measured. Quantity divided by approximate volume yields approximate density.

Calculations - Quantity: 5,160 pounds (weighed)

Approx. Volume: 14.83' X 11.25' X 3.75' = 625 cu ft
÷ 27 cu ft/cu yd = 23.1 cu yd

Density: 5,160 pounds ÷23.1 cu yd = 223 pounds/cu yd
= 2.23 tires/cu yd = 11.2 PTE/cu yd

Comments - This test illustrates the difficulty in attempting to approximate actual pile conditions through non-representative tests of small, irregularly-shaped piles.

Impact - This test has no impact on quantity estimates or abatement plans. No piles containing loose truck tires were included in previous quantity estimates. Most of the truck tires accumulated recently in the area south of the transport trailers have been placed in rows, oriented, or piled deeper than the test so actual densities will necessarily differ from test results.

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SHREDDED TIRES

In-Place Pile Density

Methodology - Shreds were removed from two measured areas within pile segments directly adjacent to initial fire lanes. Shreds were placed in a truck (previously weighed empty) and weighed on the site scale. The first site was intended to represent finer shreds, although large shreds (some close to half tires) were observed. The second site was intended to represent coarse shreds typical of those contained within most of the pile. The net weight of the removed shreds in each test divided by the excavated volume yields shred density.

First Test Area ("Finer" Shreds)

Calculations - Weight: Gross - Tare = Net shred weight

Truckload 1: 54,820 - 30,280 = 24,540 lbs
Truckload 2: 53,340 - 30,280 = 23,060 lbs
Truckload 3: 54,960 - 30,280 = 24,680 lbs

Total Net Weight = 72,280 lbs

Volume : Roughly rectangular area

Height: @back = 12.67 ft , @front = 13.75 ft
Average = 13.2 ft
Width: 14 ft
Length: 9.5 ft
Volume: 13.2 X 14 X 9.5 = 1,756 cu ft

Density: Weight ÷ Volume = Density

72,280 lbs ÷ 1,756 cu ft = 41.2 lbs/cu ft

Comments - Shreds were removed from a rectangular area at the junction of fire lanes rather than directly within the pile, so some shreds slid outside the area and were not captured and weighed. Small quantities of shreds fell from the loader bucket prior to dumping into the truck. It was also more difficult to measure the excavated area.

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Impact - The selected area was estimated to have a density of 40 pounds/cubic foot in previous quantity calculations. The tested density is 1.2 pounds/cubic foot, or approximately 3%, greater than the estimated density and would increase the on-site quantity proportionately.

Second Test Area (Coarse Shreds)

Calculations - Weight: Gross - Tare = Net shred weight

Truckload 1: 48,560 - 30,280 = 18,280 lbs
Truckload 2: 47,460 - 30,280 = 17,180 lbs
Truckload 3: 50,180 - 30,280 = 19,900 lbs

Total Net Weight = 55,360 lbs

Volume : Triangular area

Height: 15 ft
Legs: left = 10.25 ft, right = 12.5 ft
Hypotenuse: 14.5 ft
Volume: 930 cu ft

Density: Weight ÷ Volume = Density

55,360 lbs ÷ 930 cu ft = 59.5 lbs/cu ft

Comments - Shreds were removed from a triangular area at the junction of fire lanes rather than directly within the pile due to loader accessibility, but shred capture appeared to be better than the first test. Small quantities of shreds still fell from the loader bucket prior to dumping into the truck. The excavated area dimensions were those provided to Mr. Kahn by Mr. Friscia, the consulting engineer engaged by Florida Tire to conduct the testing.

Impact - The selected area was estimated to have a density of 38 pounds/cubic foot in previous quantity calculations. The tested density is 59.5 pounds/cubic foot, or approximately 57%, greater than the estimated density and would increase the on-site quantity proportionately. However, the tested density is unusually high for a compacted pile of coarse shreds, indicating that there was either an error in measurement or that the result was influenced by contamination within the shred pile. If the result is due to extensive contamination, then any ultimate transport and disposal costs that are based on weight will increase proportionately unless the contamination is removed prior to disposal.

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Loose Shred Density

Methodology - Shreds were loaded directly from the processing equipment into trucks, leveled by manual raking to predetermined side benchmarks, and then weighed. Truck bed dimensions were measured to allow volume calculation. Net shred weight divided by volume yields average density. Tests were conducted on finer (nominal 2 inch) shreds from the CM shredder and on coarse (one-pass) shreds from the SSS shredder (bypassing the recycling trommel).

Finer Shreds

Calculations - Weight = 33,540 lbs - 23,500 lbs = 10,040 lbs

Volume (nominal) = 14.42' X 7.08' X 3.08'
= 314.4 cu ft = 11.65 cu yd
(actual) = 14.42' X 7.08' X 3.33'
= 340 cu ft = 12.6 cu yd

Density (nominal) = 10,040 lbs ÷ 314.4 cu ft
= 31.9 lbs/cu ft
= 862.2 lbs/cu yd
(actual) = 10,040 lbs ÷ 340 cu ft
= 29.5 lbs/cu ft
= 797.3 lbs/cu yd

Comments - Implementation of this test involved three fundamental flaws that influenced test results. First, a water spray operating in the shredder box introduced up to 1,000 pounds of water (3 gpm X 8.34 pounds/gal X 40 minutes) that is not considered basic tire weight since it was not part of the tire input weight. Second, the truck was unintentionally overfilled then raked level to an actual height estimated to be 3 inches above the intended (nominal) pre-measured height. Third, personnel movement and raking have a compaction impact that increases effective density compared to shreds that are just dumped into a loose pile. If the water weight is subtracted and actual volume is used, effective adjusted density becomes:

Density (adjusted) = 9,040 pounds ÷ 340 cubic feet
= 26.6 lbs/cu ft = 718 lbs/cu yd

Impact - Since most shreds (estimated to be over 90%) on-site are coarse and the adjusted density differs by less than 3% from TAG's estimated 700 pounds/cubic yard, this test has little practical impact upon the maximum quantity that can be stored on-site.

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Coarse Shreds

Calculations - Weight = 49,880 lbs - 30,280 lbs = 19,600 lbs

Volume = Gross bed - sloped corners adjustment
= (7.83'x 20.17'x 4.63') - 32.2 cu ft
= 699 cubic feet

Density = 19,600 lbs ÷ 699 cu ft
= 28 lbs/cu ft = 756 lbs/cu yd

Comments - This test involved shredding tires containing trapped water from outdoor storage piles, with this water effectively increasing shred weight. If this result were adjusted by 8% to reflect water that Florida Tire felt was responsible for the 108 pounds/tire average weight of whole truck tires (versus projected dry weight of 100 pounds/tire), the effective density would be 700 pounds/cubic yard.

Impact - This test result will have minimal impact on projected maximum on-site storage quantities. TAG projected 700 pounds/cubic yard in its estimates, equal to the effective density from the test. Even at 756 pounds/cubic yard, it would increase the maximum storage quantity by only approximately 3,000 tons and would decrease the quantity that must be removed from the site to 15,350 tons versus 18,350 tons.