A Case Study of Scrap Tire Disposal in North Carolina

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Abstract: North Carolina law states that whole tires were banned from landfills as of March 1, 1990. Used tires disposed in landfills do not decompose for several years and tend to disrupt landfill covers by rising to the surface. In 2011-12 approximately 145 thousand tons of scrap tires were reported in North Carolina. These tires were used for fuel, either in shredded form known as tire-derived fuel (TDF) or whole, depending on the type of combustion device. Best practices have shown that tires need to be reduced in size to fit in most combustion units. TDF is one of several alternatives to prevent newly generated scrap tires from inappropriate disposal in tire piles, and for reducing or eliminating existing tire stockpiles. Scrap tires represent both a disposal problem as well as a resource opportunity. There are several potentially negative environmental and health impacts associated with scrap tire piles. This study focuses on an examination of North Carolina's disposal and usage of scrap tires.

Keywords: Tire derivative fuels, scrap tires, tire combustion.

1. INTRODUCTION

In the United States, the dominant force behind control and reduction of scrap tires is the maintenance of stockpiles. North Carolina's 1990 adoption of regulations regarding tire stockpiles and the regional coordination of neighboring states have lessened the incidence of illegal scrap tire storage and disposal. However, local regulations have had limited impact on controlling statewide scrap tire movement and accumulation. Scrap tires can be transported short distances inexpensively, so they usually are moved to the nearest unregulated jurisdiction or the destination with the lowest disposal cost. Concerns over the costs and threats associated with large stockpiles as well as the increase of new stockpiles have driven most legislation in the United States. The Scrap Tires: Handbook on Recycling Applications and Management for the U.S. and Mexico provides a documented resource for federal, state, and local governments along with private industry in developing markets for the prized resources contained in scrap tires [1].

II. RESEARCH REVIEW OF LITERATURE ON SCRAP TIRES

The literature pertaining to the end use of used tires has been limited. A report prepared by Michael J. Pegg *et al.* in 2000 as they conducted a life cycle analyses (LCA) of tires showed that cryogenic pulverization is the most harmful to the environment, followed by mechanical pulverization. A number of LCA have shown that using tires as a substitute for coal in cement kilns does less harm to the environment than other end-of-use options. A critical review of reported emissions studies showed significant variation in all the emission data. There appeared to be a definite decrease in NOx when tires are used a supplemental fuel. Sulfur dioxide emissions come primarily from the coal and ore feedstock and do not appear to readily correlate with the use of tires. Additionally information revealed in their study was that when burning tires, CO emissions are higher. In general, most metal emissions increase, particularly zinc. Emission levels of dioxins/furans reported in the literature show large variability.

On a weight basis the use of scrap tires in the US as tire derived fuel (TDF) has been steadily increasing since 1990 and in 2006 accounted for 59.3% of all tires. This is an important and profitable use for scrap tires as fuel. Tire-derived fuel (TDF) is a fuel derived from scrap tires of all types. This may include whole tires or tires processed into uniform, flowable pieces that satisfy the specifications of the purchaser. Scrap tires can be used as fuel, either shredded or whole depending on the type of combustion unit [2,3].

TDF is the oldest and most developed market for scrap tires in the U.S. Industrial facilities across the country, including cement kilns, pulp and paper mills, and electric utilities use TDF as a complementary fuel to increase boiler efficiency, decrease air emissions, and decrease costs. More than 52 percent of the 300 million scrap tires generated annually are disbursed as TDF in these facilities, providing a cleaner and more economical substitute to traditional fuels.

The U.S. Environmental Protection Agency (EPA) described TDF as a high Btu-value fuel with considerably less emissions, including less greenhouse gas emissions, than comparable traditional fuels, in a

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2009 Advanced Notice of Proposed Rulemaking. In earlier studies, EPA concluded, "With proper emission controls, burning tires for their fuel energy can be an environmentally sound method of disposing a difficult waste. It is because of their high heating value that TDF are seen as an asset. When comparing TDF to other commonly used solid fuels, the heating value is 25-50% higher than coal and 100-200% higher than wood." Scrap tires that are removed from stockpiles only have two uses in the current markets: TDF and limited civil engineering applications. Historically, tires in piles become contaminated with water, dirt and other remains. Unfortunately, it is the "remains" that keep scrap tires from being used in other rubber applications [4].

The following statements are from an EPA research paper on use of TDF in 1997. "TDF can be used successfully as a 10-20% supplementary fuel in properly designed fuel combustors with good combustion control and add-on particulate controls, such as electrostatic precipitators, or fabric filters. Furthermore, a dedicated tire-to-energy facility specifically designed to burn TDF as its only fuel has been demonstrated to achieve emission rates much lower than most solid fuel combustors. No field data were available for well-designed combustors with any add-on particulate controls. Laboratory testing of a Rotary Kiln Incinerator Simulator (RKIS) indicated that efficient combustion of supplementary TDF can destroy many volatile and semi volatile air contaminants. However, it is not likely that a solid fuel combustor without add-on particulate controls could satisfy air emission regulatory requirements in the US" [5].

Scrap tires make an excellent fuel because of their high heat value. Each tire has energy potential. The heating value of an average size passenger tire is between 13,000 and 15,000 Btu/lb., which compares with about 10,000 to 12,000 Btu/lb. for coal. The primary reason for using tire fuels is to reduce fuel costs. In addition to cost savings scrap tires are compact; they have a consistent composition, and exhibit lower moisture content. These are all advantages to the fuel user. Another major reason for combusting tires as fuel is to reduce the number of scrap tires disposed in landfills or stockpiles.

Nationally, scrap tires represent a potential energy source of 1.01 quadrillion Btu per year, based on a discard rate of 300 million tires per year, each weighing an average 22.5 lbs with 15,000 Btu per pound. This is equivalent to 17 million barrels of crude oil and represents approximately 0.24 percent of the U.S. energy needs. Given this energy value, it is clear that scrap tires parallel with comparable traditional fuels including coal, petroleum coke, and wood wastes.

While some combustion devices, typically cement kilns, can accept tires whole, most combustion devices require the tires to be processed to certain sizes and purity to confirm that the material consistently meets the needs of the particular fuel purchaser. Shredding scrap tires to produce TDF uses accepted material processing technology which includes shredding and removing dirt or other pollutants.

Processing tires into TDF involves two steps which include chipping/shredding and metal removal. This process consists of feeding the tires into the shredder whole and or having the beads removed prior to shredding. The processing equipment is generally high-shear, low-torque shredders. Scrap passenger and truck tires up to 48 inches in outside diameter can be initially reduced in these rotary shear shredders to pieces ranging in size from 1" to 4", depending on the needs of the purchasers.

In order to produce TDF-size shreds and chips, whole tires are minimized to nominal two-inch pieces using one shredder or a series of shredders, screening equipment and magnetic separation equipment. Magnetic separators are necessary to remove the steel. A screen in the discharge of the shredder controls the shred/chip size where the two-inch sized material falls through the screen openings while the oversized material is re-circulated back to the shredder. Because a significant amount of rubber is tangled and lost in the wire removal stream, downstream shredding and wire removal can be employed to recover additional rubber, make a cleaner steel product for sale as scrap and to avoid landfilling this wire/rubber material. If smaller-sized TDF (1-inch or crumb rubber) is specified, then more size reduction, metal and fiber separation, classifying, screening, and cleaning equipment may be required.

TDF has the flexibility to be used in a variety of industries including cement manufacturing, pulp and paper industry, electric utilities, and tires-to-energy facilities.

Cement manufacturing companies use whole tires and TDF in addition to their primary fuel for firing cement kilns. The characteristics that make scrap tires an excellent fuel for the cement kiln are: (1) the very high temperatures, (2) the long fuel residence time in the kiln allow complete combustion of the tires, (3) there is no smoke, odor, or visible emissions from the tires, (4) the ash is incorporated into the final product which means there is no waste, and (5) the metal wire contained in the TDF is captured as a raw material or ingredient in the cement making process. Each passenger car tire contains about 2.5 pounds of high-grade steel. The steel portion of the tire becomes a component of the cement product, thereby replacing some or all of the iron required by the cement manufacturing process.

The Portland Cement Association (PCA) reported in a 2008 study of emissions the use of tires as fuel can reduce certain emissions. This PCA study of emission tests from 31 cement plants firing TDF revealed that there were no statistically significant differences in the emission data sets for sulfur dioxide, nitrogen oxides, total hydrocarbons, carbon monoxide, and metals between kilns combusting TDF and non-TDF firing kilns. Additionally, separate studies conducted by governmental agencies and engineering consulting firms have also indicated that TDF combustion either reduces or does not significantly affect emissions of various contaminants from cement kilns [6].

In a 2007 study, the United States Department of Energy estimated that the combustion of TDF produces less carbon dioxide (CO_2) per unit of energy than coal. This means that when TDF replaces coal in a Portland cement kiln, less CO_2 will be produced. [USDOE 2007].

Long-term experience and statistical tests have shown that tires are being used successfully in cement kilns and good quality cement products are being made while using scrap tire fuels. Higher production rates, lower fuel costs, and improved environmental quality achieved when tire fuels are combusted in cement kilns continue to define scrap tires as a viable fuel choice for cement kilns.

Pulp and paper companies use tire-derived fuel as an additive to wood waste which is the primary fuel used in pulp mill boilers. The technology is proven and has been in continuous use in the U.S. since the early 1980s. The heating value of the wood waste fuel ranges from about 7,900 to 9,000 Btu/lb. on a dry basis. TDF's higher heat value of 15,000 Btu/lb. facilitates uniform boiler combustion, and helps to disable some of the operating problems caused by fuels with low heat content, variable heat content, and high moisture content. The consistent Btu value, low moisture content of TDF, and the low cost in contrast to other supplemental fuels make TDF an especially attractive fuel in the pulp and paper industry. Additionally, pulp and paper mills have the ability to burn TDF without major equipment modifications which offers another plus for the use of TDF.

Pulp and paper mills continue to increase their use of TDF to help lower fuel costs and increase both emissions and combustion efficiency. The use of TDF in pulp and paper mill boilers also aids the mills in improving their public image in their localities as they seek to improve environmental responsibility. The following variables have led to the increase in the number of paper mills using TDF technology; (1) high energy costs, (2) improved reliability in the TDF processing industry, and (3) the consistent product quality of TDF

Electric power utilities use TDF as a supplemental fuel to produce power in boiler operations. Boilers at electric power plants use fuel to generate power for municipalities and industries. In the electric power industry, TDF is used mainly as an additive to other fuels, primarily coal. Since electric power utilities are so diverse, TDF must be correlated to fit the fuel conveyors and blended to ensure proper combustion. In electric power utility applications, TDF provides an economic fuel with constant Btu content and low moisture. Electric utilities also found that the quality of emissions actually improves with the increased use of TDF as an additive fuel. TDF remains an attractive fuel for the electric power generating industry due to the following: (1) the higher heating value, (2) a lower emissions rate, (3) the competitive cost, and (4) the ability to create stable operating conditions in the boiler.

The norm for most industrial and institutional boiler systems is a TDF sized 2-inch x 2-inch or less and 95 percent free of wire. The combustion of tire-derived fuel creates energy in the form of steam and/or electricity which replaces the need to create energy from other power generating facilities and from additional fuels. The use of TDF for energy reduces the need for certain fuels which ultimately reduces the emitted pollution emitted. TDF combustion in industrial boilers can emit less sulfur dioxide and nitrogen oxide than most types of coal when measuring on a net energy output basis. TDF and their usage in boilers must conquer the challenges of increased use due to plant closings, depressed markets, and other economic circumstances.

The Environmental Protection Agency stated that, "EPA supports the highest and best practical use of scrap tires in accordance with the waste management hierarchy; in order of preference: reduce, reuse, recycle, waste-to-energy, and disposal in an appropriate facility. The disposal of scrap tires in tire piles is not an acceptable management practice because of the risks posed by tire fires, and because of the use of tire piles as a habitat by disease vectors such as mosquitoes." The use of scrap tires as tire-derived fuel (TDF) is one of several feasible alternatives to avoid newly generated scrap tires from landing in tire piles,and for reducing existing tire stockpiles.

Based on 15 years of testing, EPA has shown that TDF has a higher BTU value than coal. These tests were based on data from more than 80 individual facilities. EPA also recognizes that the use of tire-derived fuel is an alternative to the use of fossil fuels, and supports the responsible use of TDF in Portland cement kilns and other industrial facilities provided that the facilities have: (1) developed a TDF storage and handling plan, (2) secured a permit for all applicable State and Federal environmental programs, and (3) are in compliance with all requirements of the permit [7].

Scrap Tire News reported in 2009 the EPA described TDF as a high Btu-value fuel with lower emissions, including lower greenhouse gas emissions, than comparable traditional fuels, in a 2009 Advanced Notice of Proposed Rulemaking. In earlier studies, EPA concluded, "With proper emission controls, burning tires for their fuel energy can be an environmentally sound method of disposing a difficult waste" [8].

The American Society for Testing and Materials (ASTM) approved ASTM 6700-01, an International Standard for TDF, in 2006. ASTM Standard D-6700-01 "Standard Practice for Use of Scrap Tire-Derived Fuel" offers end-users and potential end-users an industry-accepted standard against which they can compare all tire chips.

The standard is listed below:

- Provides definitive parameters for size, distribution, sampling and testing
- Provides a single sampling and testing protocol
- Provides guidance for the material recovery of scrap tires for their fuel value
- Explains TDF use when blended and combusted under normal operating conditions with originally specified fuels [9]

III. SCRAP TIRE DISPOSAL PROBLEMS

According to the Environmental Protection Agency, Americans generate about 285 million scrap tires per year. Tire piles are excellent surroundings for mosquitoes. Due to the shape and protection of tires, they provide breeding sites for mosquito larvae development. Two species of mosquitoes are dominant in the southern United States. These two species (Aedes aegypti and Aedes albopictus) are known to be the principal carriers of Yellow Fever and Dengue disease.

Tire stockpiles also have contributed to the introduction of non-native mosquito species when used tires are transported to the United States. The new species are often more difficult to control and spread more disease. Aedes albopictus (the "Asian Tiger Mosquito") merits special consideration. This species was accidentally transported from Japan to the western hemisphere in the mid-1980s in shipments of used tires. It has since become established in at least 23 states. It is considered the nation's most dangerous species [10].

In 1995 a study was conducted by O'Meara on waste tires and other types of artificial containers were sampled for immature Aedes to monitor changes in the occurrence of Aedes aegypti (L.) and Aedes albopictus (Skuse) in Florida. The initial invasion and spread of these mosquitos in Florida occurred in the northern part of Florida. In southeastern Florida, these mosquitos were persistent in thriving populations as the dominant container-inhabiting bugs in urban areas, whereas sites dominated by undeveloped tracts of land within urban or suburban areas. At some locations, immature mosquitos were found in the containers and tires.

The elimination of scrap tire piles will eliminate a huge mosquito habitat along with the correlated disease risks. The spread of the Asian Tiger Mosquito has been increased by state transport of scrap tires. Several states have even banned the transport of scrap tires, especially for larger supplies of tires. Waste tires and waste tire stockpiles are difficult to ignite and difficult to extinguish. This is due to the 75% void space present in a whole waste tire, which makes it almost impossible to smother the tires with water or to eliminate the oxygen supply. The shaped of the tire casings and the low air drafts tends to strengthen the fire [11].

A large tire fire can rage for several weeks or even months, sometimes with dramatic effect on the surrounding environment. As an example in 1983, a 7-million tire fire in Virginia burned for almost nine months, polluting nearby water sources. The air pollutants from fires include dense black smoke which distorts visibility and soils painted surfaces with oil. The toxic gas emissions from these tire fired include polyaromatic hydrocarbons, CO, SO_2, NO_2, and HCl. Increased and long term burning enlarges the likelihood of surface and groundwater pollution. Using water to extinguish a tire fire does not always work in rural areas due to the availability of water resources. Smothering a tire fire with dirt or sand is the best option for extinguishing tire fires. Moving sand or dirt is with heavy equipment to cover the burning tires usually faster and cheaper than foams or water.

The Environmental Protection Agency (EPA) stated in 1992 that “emissions from open tire fires have been shown to be more toxic than emissions from an incinerator, regardless of the type of fuel. Airborne emissions from open tire fires can have a serious impact on health and the environment. Open tire fire emissions include “criteria” pollutants, such as particulate, carbon monoxide (CO), sulfur oxides (SOx), nitrogen oxides (NOx), and volatile organic compounds (VOCs). They also include “non-criteria” hazardous air pollutants, such as polynuclear aromatic hydrocarbons (PAHs), dioxins, furans, hydrogen chloride, benzene, polychlorinated biphenyls (PCBs); and metals, such as arsenic, cadmium, nickel, zinc, mercury, chromium, and vanadium.”

Data from a laboratory test program conducted by the EPA in 1993 showed that open tire fire emissions contain 16 times more mutagenic compounds than from residential wood combustion in a fireplace, and 13,000 times more mutagenic compounds than coal-fired utility emissions with good combustion efficiency and add-on controls. The emissions from an open tire fire can create significant short-term and long-term health hazards to those who are close to the burning area. These health effects can include irritations of the skin, eyes, and mucous membranes, respiratory effects, central nervous system depression, and cancer.

IV. SCRAP TIRE OPPORTUNITIES

Many fossil fuels contain hydrocarbons. If we compare pound for pound, tires have more fuel value than coal. Hundreds of millions of used tires are stock piling annually in the United States. By just disposing of these unwanted tires, we miss an important recycling opportunity: the chance to restore energy and to save our resources of fossil fuels. A great example is the use of TDF in the cement making process.

The intense heat of the kiln ensures complete destruction of the tires. There is no smoke or visible emissions from the tires. In fact, the use of tires as fuel can actually reduce certain emissions. Many applications have benefitted from the use of scrap tires as a supplemental fuel in the Portland cement manufacturing process. When whole tires are combusted in cement kilns, the steel belting becomes a component of the clinker which replaces some or all of the iron required by the manufacturing process.

In 2008, Portland Cement member companies completed a study on the impact of TDF firing on cement kiln air emissions. The study’s data set included emission tests from 31 of the cement plants that were firing TDF. Dioxin-furan emission test results indicated that kilns firing TDF had emissions approximately one-third of those kilns firing conventional fuels; this difference was statistically significant.

Additional testing from the data set revealed that emissions of particulate matter (PM) from TDF-firing kilns were 35% less than the levels reported for kilns firing conventional fuels. Nitrogen oxides, most metals, and sulfur dioxide emissions from TDF-firing kilns also exhibited lower levels than those from conventional fuel kilns. The emission values for carbon monoxide and total hydrocarbons were slightly higher in TDF versus non-TDF firing kilns. None of the differences in the emission data sets between TDF versus non-TDF firing kilns for sulfur dioxide, nitrogen oxides, total hydrocarbons, carbon monoxide, and metals were statistically significant.

Separate studies conducted by governmental agencies and engineering consulting firms have also indicated that TDF firing either reduces or does not significantly change the emissions of various contaminants from cement kilns. Under their program for the voluntary reporting of greenhouse gases, the United States Department of Energy (USDOE) estimated that the combustion of TDF produces less carbon dioxide (CO_2) per unit of energy than coal [USDOE 2007a]. This means that when TDF replaces coal in a Portland cement kiln less CO_2 will be produced [12].

The European Tire and Rubber Manufacturers reported in 2007 that the use of TDF is common in other parts of the world. In Japan, there were 103 million scrap tires generated in 2006 with 16% being used as a fuel in the cement industry. For that year, Japan recycled 54% of all scrap tires through heat utilization [JATMA 2007]. Of the approximately 3.2 million metric tons of scrap tires handled annually in Europe, 31.6% are directed to energy recovery systems including Portland cement kilns [13].

The 2012-2013 ETRMA Annual Report stated that Europe generated approximately 3.3 million tons of used tires. An estimated 2.7 million tons of scrap tires were left to be treated. The TDF fraction was used in many applications including rubber infill in synthetic turf soccer fields, athletic tracks, bitumen modifier in asphalt, civil engineering, and landscaping [14].

The number of cement plants utilizing scrap tires in the United States as a supplemental fuel has risen dramatically over the last 19 years. As of 2006, state and local environmental agencies have approved the use of TDF at 48 plants in 21 states.

V. DISPOSAL OF SCRAP TIRES IN NORTH CAROLINA

The North Carolina Division of Waste Management administers a comprehensive program to manage scrap tires. This program prevents illegal dumping of tires by providing an infrastructure to safely collect, store, and recycle scrap tires. An advance disposal fee is charged when new tires are sold. The proceeds are distributed to each county to pay for collection and recycling of tires. Counties do not charge disposal fees for tires generated in North Carolina. Each load of more than five tires must be accompanied by a completed scrap tire certification form.

All North Carolina counties are required to provide a facility for scrap tire collection and to report on their management programs. In FY 2010-11, North Carolina businesses and individuals disposed of approximately 152,006 tons of tires. These tires were operated and managed by county collection facilities and private processing/disposal facilities as follows: 122,206 tons were operated and managed by counties and shipped to two N.C. processing firms, 1,508 tons were operated and managed by counties and shipped to out-of-state processors, 28,292 tons of tires were taken directly to processing firms (privately-funded cleanups or tire dealers not participating in a county program).

In addition, the two NC processors received 37,918 tons of tires from other states. The tire program's success is illustrated by the number of tires properly disposed at permitted facilities. When free disposal was implemented in 1994 for scrap tires generated in the normal course of business in North Carolina, a potential problem emerged: the illegal free disposal of out-of-state tires at county collection sites. North Carolina counties like others in the U.S. must be thorough in their screening process for scrap tires brought for disposal in order to identify out-of-state tires and other tires not eligible for free disposal. Those counties that are not thorough in their examination will spend a large portion of their tire tax revenues for the disposal of out-of-state tires. The North Carolina Division of Waste, Solid Waste Section is to assist counties in learning how to avoid fraudulent disposal of out-of-state tires through guidance, technical assistance, regulations, permitting, environmental monitoring, compliance evaluation and enforcement. The waste types handled at these NC facilities include municipal solid waste, industrial waste, construction and demolition waste, land-clearing waste, scrap tires, medical waste, compost, and septage. County efforts to deter disposal of out-of-state tires are a very weighty factor when awarding grants in North Carolina which cover cost over-runs.

In North Carolina there are 97 county programs and one regional program [Coastal Regional Solid Waste Management Authority includes Carteret, Craven, and Pamlico Counties]. In 2011-2012 these programs reported spending a total of $11,787,479.39 for scrap tire management and disposal. Of this total, $11,198,657.28 was for direct disposal costs and $588,822.11 was for other costs, such as labor or equipment costs. Counties that experienced low costs were stockpiling tires during the year rather than sending them for processing. Some of the variance is due to recordkeeping errors or county reporting errors. Some counties manage tires more efficiently than others. For example, counties that allow citizens to dispose tires at multiple recycling facilities or provide curbside pickup incur increased labor costs to recover and load tires into trailers. An analysis indicates that cost of disposal is an average of $103 per ton of scrap tires at recycling/disposal facilities.

North Carolina County programs annually report the amount of scrap tire tonnages and costs per ton. The costs are reported on the Section website at: County Reports of Tonnages, Costs, Revenue, Cost per Ton. The information on the website was taken from N.C. Department of Revenue reports of tire tax distribution and from the Scrap Tire Management Annual Reports submitted by each of the 100 counties.

In FY 2010-11, 75 percent of scrap tires received by North Carolina tire recycling companies were recycled. In order of weight recycled, the categories are: tire-derived fuel, crumb/ground rubber, civil engineering (including drain field material), recap/resale and other products. The remaining tires go to the two permitted tire monofills in the state. The market for tire-derived fuel (TDF) although strong in recent years, saw a 12 percent decrease during FY 2010-11 from the FY 2009-10 amount.

In FY 2011-12, the total collection of scrap tires in N.C. was 144,461.8 tons. The total revenue from these tires was $11,889,644.95 while the cost of collecting these tires was $14,737,202.67. The average cost per ton for the state of North Carolina was $103.43 per ton. Approximately 10% of all counties in N.C. have costs higher than the average cost per ton [16].

VI. RECOMMENDATIONS

"The mutagenic emission factor for open tire burning is the greatest of any other combustion emission studied. Studies by Lemieux and DeMarini found that tire burning is 3-4 orders of magnitude greater than the mutagenic emission factors for the combustion of oil, coal, or wood in utility boilers" [17].

Field sampling data from uncontrolled open tire fires in North Carolina is lacking. This is a result of the inherent difficulties encountered in obtaining the data due to safety concerns and the variable nature of the event (e.g., fire size and duration, meteorological conditions, terrain effects, combustion conditions and fire-fighting activities). Furthermore, the primary concern on the part of officials in charge is to provide for the safety and welfare of those who may be affected by the heat and smoke from the fire.

Whether burning TDF in a new facility or as a modification to an existing facility, several issues must be considered. One consideration is the need to convert scrap tires into a useable fuel. This requires a system to dewire, and shred, or otherwise size the tires so they can be accommodated by a combustor. In addition to aiding in feeding, the sized fuel generally allows for more efficient combustion. However, some large combustor configurations, such as cement kilns, wet-bottom boilers, and stoker-grate boilers can be modified to accept whole tires. Modifications to hardware, combustion practices and/or other operating

The following companies below found at the North Carolina Department of Revenue 2012 accepted "tires" from N.C. for burning for tire-derived fuels:

Companies in N.C. Accepting Tires for TDF	
Company Name	**City**
Advanced Disposal Systems of the Carolinas	Charlotte
All Points Waste Service	Garner
Brays Recapping Service	Mount Airy
Carolina Disposal Service, Inc.	Lexington
Central Carolina Tire Processing	Cameron
Elastrix, LLC	Pilot Mountain
Gladden Tire Disposal	Charlotte
Jackson Paper Manufacturing Co.	Sylva
Junk Rescue Company	Charlotte
New East Recycling and Container Service, Inc.	Greenville
PalletOne, Inc NATIONWIDE POST INDUSTRIAL RECYCLING DIVISION	Newton
Polymer Technologies Inc.	Raeford
Rubber Mulch Unlimited	Mooresville
Trashies Waste Management	Stella
U.S. Tire Recycling, L.P.	Concord
We Recycle Tires	Salisbury
White's Tire Service of Wilson, Inc.	Wilson

practices may also be necessary in order to burn TDF. These modifications are case-specific, and must be addressed by engineering staff when considering using TDF.

REFERENCES

[1] The Scrap Tires: Handbook on Recycling Applications and Management for the U.S. and Mexico, Environmental Protection Agency, EPA 30-10-010, December 2010.

[2] Pegg MJ, Amyotte PR, Fels M, Cumming CRR, Poushay JC. Tire Use Alternative Use Fuel Assessment. Available from: http://www.novascotia.ca/nse/waste/docs

[3] AEA Technology. Environmental Technology Best Practice Programme Life-Cycle Assessment - An Introduction For Industry 2000. Available from: http://www.tangram.co.uk/TI-Life_Cycle_Assessment_(ET257).pdf

[4] http://www.epa.gov/waste/conserve/materials/tires/tdf.htm last accessed 11/27/2013.

[5] http://www.epa.gov/ttn/catc/dir1/tire_eng.pdf last accessed 11/26/2013.

[6] Air Emissions Data Summary for Portland Cement Pyroprocessing Operations Firing Tire-Derived Fuels, PCA R&D Serial No. 3050, John Richards; David Goshaw; Danny Speer, and Tom Holder, Portland Cement Association, Skokie, IL, USA 2008.

[7] http://www.epa.gov/osw/conserve/materials/tires/tdf.htm last accessed 11/17/2013.

[8] Scrap Tire News: Available from: http://www.scraptirenews.com/tdf.php

[9] ASTM 6700-01 Standard Practice for Use of Scrap Tire-Derived Fuel 2006.

[10] Management of Scrap Tires – Tire-Derived Fuel, United States Environmental Protection Agency, Washington, DC, USA, September 7, 2007b. http://www.epa.gov/epaoswer/non-hw/muncpl/tires/tdf.htm.

[11] O'Meara GF, Evans LF Jr., Gettman AD, Cuda JP. J Med Entomol 1995; 32(4): 554-62.

[12] Rule 1161 – "Portland cement kilns," (Adopted: 06/28/95; Amended: 10/22/01; Amended: 03/25/02), Mojave Desert Air Quality Management District, California Air Resources Board, Sacramento, CA, USA, 2002. http://www.arb.ca.gov/drdb/moj/curht¬ml/r1161.pdf

[13] End of Life Tyres Management in Europe, European Tyre and Rubber Manufacturers' Association, Brussels, Belgium, July 2007. Available from: http://www.etrma.org/public/activitieseoflttrenf.asp

[14] ETRMA Annual Report 2012 – 2013, Available from: http://www.etrma.org/uploads/Modules/Documentsmanager/etrma_annualreport-2012-2013.pdf

[15] Lemieux M, Ryan JV. Characterization of Air Pollutants Emitted from a Simulated Scrap Tire Fire. J Air Waste Manag Assoc 1993; 43: 1106-15. http://dx.doi.org/10.1080/1073161X.1993.10467189

[16] The North Carolina Department of Revenue, 2012. http://portal.ncdenr.org/c/document_library/get_file?uuid=44445cf8-407f-4dc7-9a44-b224cd1b8bee&groupId=2444522

[17] Lemieux PM, DeMarini D. Mutagenicity of Emissions from the Simulated Open Burning of Scrap Rubber Tires, U.S. Environmental Protection Agency, Control Technology Center, Office of Research and Development, EPA-600R-92-127 (NTIS PB-92-217009), July 1992.

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