

THE USE OF SCRAP TIRES

IN CEMENT ROTARY KILNS©

SCRAP TIRE MANAGEMENT COUNCIL

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FORWARD

The Scrap Tire Management Council was established in 1990 by the North American tire manufacturers. The Council's primary objective is to assist in the development and promotion of markets that meet two criteria. First, the use (or market) must be environmentally sound, and second, economically viable. In 1990 the Council sponsored an evaluation of markets for the use of scrap tires.

Two markets, both having large-scale, consumption potential were identified. These markets were as a supplemental fuel (whole or processed tires) and as ground rubber for asphalt pavement. The largest potential fuel market identified by this evaluation was cement kilns.

To expand the use of scrap tires in cement kilns, the Council has prepared this report that describes the use, destruction and energy recovery of whole or processed scrap tires in rotary kilns [for the purposes of this report, whole or processed scrap tires used as a supplemental fuel will be referred to as TDF - tire derived fuel].

This report may not answer all the technical aspects relative to the use of TDF. It does, however, supply information and suggested strategies that can answer many of your initial questions concerning the use of TDF. The information supplied herein are suggested procedures based on field experience and conversations with kiln operators using TDF, and are not representative of my given technology. The actual procedure or protocols used at your facility may vary, due to environmental requirements or different conditions at your plant. Furthermore, this report is not the only means of support the Scrap Tire Management Council is prepared to offer. After reading the report, we trust you will have additional questions. The Council would be glad to arrange a visit in which the technical, regulatory and supply aspects of this matter can be further discussed.

I.MANUFACTURE OF CEMENT

The raw materials for cement consist of limestone (calcium carbonate), clay (alumina), sand (silica), and iron (in almost any form). These materials are blended in an exact recipe in accordance with the chemistry of each component. Cement is made by injecting the raw materials into a cement kiln and heating the materials to a temperature range of 2650 to 2750 degrees Fahrenheit (°F). At this temperature the formation of tricalcium silicate, or ALITE, the principal compound of portland cement clinker, occurs.

To arrive at this temperature, a flame temperature of 3500°F is necessary. All kilns are inclined, higher at the raw meal feed end than at the discharge end. Kilns incline from the feed end to the discharge end at one-quarter inch to one-half inch per foot of length. Kilns revolve at a rate of one to three revolutions per minute. The combination of the kiln incline and the revolving cause the raw feed and clinker to move through the kiln. (The schematic drawing below illustrates a preheater precalciner kiln.)

A time/temperature situation is necessary for the clinkering phenomena to occur. A positive oxygen atmosphere is also necessary for quality clinker to form. Fuels are injected into the low end of the kiln (see #4 on **Figure 1**) and the gases of combustion flow upward to the discharge end. Thus, the gases of combustion and the raw meal flow in opposite directions. The clinker falls out of the kiln at the lower, or discharge, end of the kiln into a clinker cooler. The clinker cooler, while cooling the clinker, conveys it to a transport system which takes the clinker to a storage area. From the clinker storage, the clinker is transported along with about 5%, by weight, gypsum to a "finish" grind mill. Other additives may be added at this point to facilitate grinding or to make a special type of cement. The cement next passes through an air classifier and either returns to the mill for further grinding, or goes to one of several storage silos.

Figure 1 Typical Preheater Cement Kiln

II.KILN CONFIGURATION

There are five basic cement kiln configurations: *i*) LONG DRY KILNS; *ii*) LONG WET KILNS; *iii*) FOUR STAGE PREHEATER KILNS; *iv*) PREHEATER-PRECALCINER KILNS; and, *v*) GRATE PREHEATER KILNS (LEPOL KILN)

LONG DRY & LONG WET KILNS

These kilns have chain systems hung near the raw meal feed end which facilitates the transfer of heat from the kiln exhaust gases to the raw meal. The chains are hung in either garlands or in curtains so that they can readily absorb the heat from the exhaust gases. These kilns range in diameter from 9 feet to 24 feet, and in length from 350 feet to 725 feet. Long dry or long wet kilns may use either whole tires or shredded tires as a supplemental fuel. Shredded tires can be fed into the kiln by insufflation, that is, blowing shreds into the discharge end of the kiln. Due to the short residence time (three to five minutes) within the kiln, the shreds should be two-inches or smaller, which assures the complete combustion of the TDF prior to falling into the clinker cooler. Another method of tire shred insertion into the kiln is by a chip cannon. This equipment can handle up to five tons of various sized chipped (or shredded) scrap tires per hour.

There are patented systems currently available in the United States that allow the feeding of whole tires into the kiln's calcining zone. These technologies could allow for an extended service life of this group of kilns, whose high fuel costs can make these facilities marginal producers of cement. (For information on these patents and/or other related equipment companies, please contact the Council.)

PREHEATER, PREHEATER PRECALCINER, & GRATE PREHEATER KILNS

These kilns range between 9 feet to 17 feet in diameter and 160 feet to 265 feet in length. Preheater-precalciner kilns may burn either shredded and/or whole tires. Two-inch chips may be fed with the coal in a precalciner. Whole or shredded tires can be fed as well in between the fourth stage and the kiln at the riser duct to the fourth stage preheater vessel.

Tires can be introduced at the riser duct to the fourth stage preheater vessel through a double tipping valve. (See schematic drawing on page 2, item 3). The tire feeding system designed at the Southwestern Portland Cement facility at Fairborn, Ohio is the system now in use by several cement kilns in the United States.

The system consists of an elevator rising to the level of the top of the kiln at the feed end. The whole tires are discharged from the elevator to a gravity conveyor. This conveyor crosses a weigh scale which sends a 4 to 20 milliamp signal to the kiln control computer. The Computer then slows or speeds the elevator to decrease or increase the feed rate of tires to the kiln. The whole tires travel down a short piece of gravity conveyor after passing the scale. This short piece

of conveyor contains a photoelectric cell. When this cell's light path is broken, it triggers a double tipping valve. This is a series of two valves used to retain the negative air pressure inside the kiln. At the end of the short piece of conveyor noted above, the first of the two valves opens. The whole tire drops by gravity through the valve. This first valve then closes and a second valve opens, allowing the whole tire to drop down a chute onto the feed shelf. The momentum of the drop and the slope of the feed shelf cause the tire to actually bounce and roll into the kiln.

When this type system was first installed around the country, whole, scrap passenger tires were the most common tires used. Recently, however, many kilns have begun, and actually prefer whole truck tires in this system. While the opening must be larger than for passenger tires, the increased weight of truck tires imbeds the larger tires more deeply into the meal. This allows for a more even distribution of heat throughout the meal, as well as a greater source of heat.

In addition to the Southwestern facility in Fairborn, this system has also been used by Southwestern Portland at Kosmos Cement in Louisville, Kentucky; Medusa in Clinchfield, Georgia; Calveras in Redding, California; and, Lafarge in Whitehall, Pennsylvania.

PRODUCTION OF CEMENT

Production rates may be increased in preheater kilns while burning whole tires. This is possible by virtue of the preheater calcination rate increasing in the preheater second and third stages when burning tires compared to the normal calcination rate while burning coal only. Calcining rates have been increased from forty-five percent burning coal only to fifty-six percent when burning whole tires. Use of tires has decreased the carbon dioxide transported by the kiln which, in turn, allows room for additional oxygen to be used in the kiln. The extra oxygen allows for the burning of additional clinker. All of the above kilns require clinker coolers to receive the burned cement clinker and cool it, and to preheat the primary, secondary and tertiary air flows which are used to burn the clinker, dry the coal, and to help calcine the raw meal (calcining will be discussed next).

As the calcium carbonate heats in the preheater of the kiln, it calcines when it is in the 1400°F to 2200°F range (calcium carbonate becomes calcium oxide plus carbon dioxide). The calcium oxide is lime, and the carbon dioxide is the gas which flows out the stack. The chemicals formed, which make up cement clinker, are tricalcium silicate, tricalcium aluminate, and tetracalcium aluminoferrite. The gases of combustion and dust particulate are drawn through the kiln and through the air pollution control device (APCD) by induced draft fan(s). The APCD may be a cyclone (multi-clone), an electrostatic precipitator, a bag house, or a combination of two of these.

DESTRUCTION OF TDF

Scrap tires (TDF) can be completely destroyed in cement kilns for a variety of sound technical reasons. The combination of extremely high temperatures (2650°F to 2750°F), a positive oxygen atmosphere and a relatively long gas residence time (4 to 12 seconds at the elevated temperatures) assures the complete combustion of the scrap tire. The complete combustion precludes products of incomplete combustion (PICs) or black smoke or odors being released from the stack. This is the main reason the use of scrap tires does not detrimentally impact the stack opacity.

III. TIRE-DERIVED FUEL

CHARACTERISTICS OF TDF

Eighty-eight percent of the tire is composed of carbon and oxygen, which accounts for its rapid combustion and relatively high heating value. Tires contain approximately 15,000 BTU's per pound. This compares favorably to coal which, on the average, contain some 12,000 BTU's per pound. Subsequently, when substituting TDF for coal, a kiln operator can reduce coal by 1.25 pounds for every pound of TDF used.

An additional advantage of TDF use is its steel portion. A 20 pound passenger car tire contains two and one-half pounds of high grade steel. The steel can substitute, in part, for the iron requirement in the raw meal recipe.

Another point of interest is that tires tend to have a lower percentage of sulfur than most coals. Sulfur in tires ranges from 1.24 to 1.30 percent by weight. Sulfur in coal ranges from 1.1 to 2.3 percent or higher, depending on the coal quality. The average coal used in cement manufacturing will run approximately 1.5% sulfur. Calcium carbonate, the largest single ingredient in cement, is one of the most effective natural sulfur gas scrubbers there is. The presences of calcium carbonate helps control sulfur emissions from a cement kiln. Emissions data from a variety of kilns has clearly demonstrated a consistent reduction in sulfur and other emissions with the use of TDF (refer to **Figure 2a-2d**). Since all the components of the tires are either destroyed, combined into the clinker or captured in the air pollution control device (APCD), there is no ash to dispose. Finally, the components of the scrap tire, once chemically combined into the clinker, are not capable of leaching out. This is comparable to silica not leaching from glass. In short, the cement kilns use 100% of the scrap tire in a completely environmentally sound manner.

COSTS CONSIDERATIONS

Another significant advantage to using whole tires is that it can lower operating costs, as compared to using 100% coal. Whole scrap tires can currently be obtained by an operating facility at a positive cost. That is, a tip fee can be assessed by the kiln operator to scrap tire transporters in exchange for the right to deliver scrap tires to the cement company. The use of scrap tires reduces the tonnage of coal used, and consequently lowers the cost associated

with the acquisition of coal. Finally, as indicated in the preceding section, the steel component of a tire can substitute for iron which reduces the cost of iron acquisition.

The use of shredded scrap tires, while not as cost effective as whole tires, typically can be obtained for less than the cost of most coals. Since no new pollution control devices are required, the only capital expenses required are a trailer storage area and a feeding system. As has been demonstrated by several of the kilns, the costs related to the use of TDF are similar to any improvement project in a cement plant. The payback period for the capital improvements is generally less than 18 months, depending upon the percentage and cost of the TDF used. The actual capital costs to construct a tire feeding system will vary, depending on the kiln configuration and technology used and the complexity of the system itself. In general, capital costs have ranged between \$200,000 and \$500,000.

Actual operating cost should change very little. The one area that may increase is the additional manning requirement. Field experience suggests that the sophistication of the feeding system affects the number of persons required to load and operate the tire feeding system. The very complex, and obviously more expensive, feeding system requires only one or zero persons to operate it. As the complexity of the system is reduced, the manning requirements increase. Maximum personnel should be 4 to 5 persons total. In the case of a one person operating per shift, this equates to 4.2 persons when considering 3 shifts a day, 7 days per week. Quality control may need an extra 0.5 person, on day shift only, to handle the extra testing suggested for the first six months of TDF use.

When adequate experience has been gained, the need for the extra quality control/quality assurance should diminish. Suggested parameters requiring observation during testing include raw materials, fuels, clinker dust, crystal structure grindability, setting times, and cement strengths (including but not limited to masonry, which may have shorter board life due to the higher strength cements).

Maintenance costs are likely to increase slightly. There should be a lower coal mill maintenance due to the reduced coal through-put; however, there will be maintenance required on the TDF feeding/weighing system that may offset this reduction. The only other initial expense encountered has been the cost to train plant personnel with the new feeding equipment and the expense of additional fire fighting equipment near the TDF conveying feeding system. The plant's fire fighting plan should be modified to reflect the additional fire protection systems installed for the TDF system.

IV.CEMENT QUALITY

The quality of the cement, whether using whole or shredded tires and regardless of the point of entry, is as good or better than when using only coal. Holnam's Ideal Seattle long straight kilns have provided better quality cement using TDF than with their basic fuel of a coal and petroleum coke mixture. Holnam uses two inch tire shreds at 2.5 tons per hour. The shreds are injected into the kiln at the discharge end by insufflation. They estimate the shreds are lofted 25 to 30 feet into the kiln. They have never had evidence of tire steel in the cooler. The clinkering zone was shortened and alite size was smaller and the clinker crystal definition was improved.

The improvement feature is the stabilization of their free lime. Prior to tire burning, free lime jumped around considerably. This stopped with the burning of scrap tires due, the Company believed, to a shorter clinkering zone brought on by the high volatility and high energy content of the TDF.

The cement quality has also improved in preheater kilns when using TDF. This is brought about by two basic facts: 1) the raw meal calcining in the preheater is increased by 22% to 25%, depending on the tire burn rate. This, in turn, has made the kilns operate more smoothly which makes for more consistent quality. 2) clinker crystal structure and clinker appearance have both improved. Clinker size is reduced as well. The combination of these improvements has been demonstrated at one plant in a two day grindability test on Type I cement. The ground cement's Wagner increased to 2140, as compared to the preceding month's 2000 Wagner average. The Blaine was 3860 compared to 3640 average for the preceding month's average Blaine. The percent passing 325 mesh increased from 94.6% average over the preceding 30 days to 96.9% for the two-day test grind.

From field experience, it is reported that there is no discernable cement color change. At Southdown's Victorville, California plant, a one million ton per year preheater-precalciner kiln made by Humboldt Wedag using a Pyroclone model R precalciner, 11.5% of total fuel in the form of two-inch tire chips was injected into the precalciner and 11.5% of the total fuel as whole tires was injected at the riser to the fourth stage of the preheater. The precalciner burned coal at 55% of total fuel under base line conditions. It was backed off to 43.5% of total fuel as coal, and 11.5% as two-inch TDF with no steel removed and 11.5% of the total fuel as whole tires injected onto the feed shelf at the feed end of the kiln. Coal feed was decreased at the discharge end of the kiln from 45% to 33.5% of total fuel. Cement quality was as good or better than base line studies. Microscopy studies revealed more discreet crystal structure.

There has not been any reported buildup of rubber in the fourth stage preheater vessel. There have been reported additional build-ups of calcined raw meal scale in the area of the feed shelf, which was easily managed. Build up on the feed shelf, which is just up from the feed end of the kiln, has occurred in a small number of preheater or precalciner kilns. The normal build up consists of lime scale or raw meal scale and is frequently removed by water blast guns or air

cannons. The build up of TDF on the feed shelf can occur due to the angle of the feed shelf being either too flat or due to the tires not being fed in a manner which allows the inertia of the tires to carry them towards into the kiln.

Other Considerations:

Historically, there has been a limit to the quantity of TDF used in a cement kiln. Heidelberg Cement (Germany), which was one of the first kilns to use TDF, has not exceeded 25% fuel substitution with TDF. There appears to be a sound reason for this limit; the combined zinc content of the TDF and other fuels may have an impact on cement quality.

TDF contains approximately 1.5% zinc. If the total zinc content of all the fuels exceeds 4,000 parts per million (PPM), there may be an increased setting time. The impact of a increased setting time is obvious. Consequently, an analysis of the total fuel stream would be beneficial to insure that zinc levels remain within an acceptable range.

V.KILN PRODUCTION RATES

The production rates in long straight kilns and preheater-precalciner kilns, at least according to the operators we have spoken with, were unchanged. Production rates in preheater kilns may well increase by virtue of calcining completed in the preheater from 20% to 25%. Increased production rates may be realized if there is fan capacity for additional oxygen, or there is cooler capacity for additional clinker, or if there is feed and grind capacity for additional raw meal. This really should not be surprising since it is the same principle that preheater-precalciner kilns use to increase production over preheater units of like size.

There have been concerns raised regarding the addition of tires at the feed end of the kiln and the possible effect of depriving the discharge end of the kiln of the heat necessary to have good clinkering action in the burning zone of the kiln.

Preheater/precalciner kilns frequently burn as high as 65% of their fuel in the precalciner and 35% at the discharge end of the kiln. When clinkering occurs, there is an exothermic reaction. That is, the clinker puts out heat when being formed. Thus the fact the 65% of the total fuel may be injected 250 feed up from the kiln where the clinkering takes place has little or no effect on the clinkering action.

In the case of preheater kilns, where 25% of the fuel is taken from the discharge end of the kiln and injected into the feed end, is a "spit in the bucket" compared to what occurs in preheater/precalciner kilns, where 65% of the fuel from the discharge end of the kiln is taken.

It should also be stated that when using TDF in precalciner kilns, fuel must be removed from the precalciner to offset the TDF injected into the feed end of the kiln.

VI. TEST METHODS

STACK TESTING

It is suggested that you should notify the appropriate governmental agencies of your intentions to test the stack before burning TDF, and request a meeting to discuss the permitting and testing protocol. At a minimum, the agencies to contact are the air quality group plus a solid waste management group who have jurisdiction over your area. Each of these agencies should be given time to discuss this subject with their departments. Many questions may arise at this stage for which the answers may require research. The Scrap Tire Management Council will be pleased to aid in this effort. Agencies should be reassured that other, similar facilities are using TDF, and that the cement company or the Council will be glad to furnish a listing of permitted facilities.

Permit forms should be sought and permitting requirements should be reviewed for future use. (It is imperative that the agencies receive the information concerning your plant's intentions from the plant manager, not from a newspaper reporter or through rumor.) Permit requirements will vary with each state. Most permits will be in two distinct parts; the air quality permit and the solid waste permit. The air quality permit may be a revision of the current kiln operating permit. The revision may be required due to the addition of a new fuel, but the use of TDF should not be considered as a new source of emissions. The second part of the permit could be to comply with the state's solid waste material handling laws. Not all states have such laws, but there are 38 states that currently have scrap tire regulations. It should be noted that scrap tires are not a hazardous material.

AIR QUALITY (AQ) PERMIT CONSIDERATIONS

Suggest to the regulatory agency that the tests for air quality emission standards are based on practices used in other states, standards developed by the US EPA, or on existing data. The following test protocol is suggested: particulate, CO, SO_x, NO_x, metals of interest to the state regulatory agency, and total unburned hydrocarbons (THC), and HCl.

Destructive removal efficiency (DRE) is a test usually associated with the burning of hazardous waste fuels (HWF), but occasionally, regulators consider TDF in the same ilk as HWF when it comes to

stack tests, so you may have to run a DRE. To do a DRE, a surrogate for hydrocarbons must be "spiked" or added to your fuel to prove the destructive removal efficiency usually to 99.99% or better removal.

A surrogate that is easily detectable in the analysis process, stable at high temperature, and not normally found in any of your raw materials or fuels should be selected. Freon 113 which is easy to detect but difficult to destroy may be the best surrogate for this use (it vaporizes at 118°F and is easily identified on a gas chromatograph).

Many states require a hydrogen chloride (HCl) test which, until a test other than that presently prescribed for incinerators is promulgated, should be contested as the test is absolutely unfair. The test, as designed, measures total chloride and then assumes that it is all HCl. This may be true for incinerators or other industrial furnaces, but it is virtually impossible for lime or cement kilns to emit HCl gases due to the calcium carbonate atmosphere in the kiln. Calcium carbonate is present in quantities exceeding ten-fold of all fuels burned in the kiln. The calcium carbonate is finely ground and is a gas scrubber unequalled in any type of furnace. What may be caught by stack testers are salts of chlorine such as KCl, NaCl, CaCl, none of which affects litmus paper, much less form HCl when dissolved in water.

The subject of lead vapor going out the stack arises far more frequently in the burning of hazardous waste in cement kilns than it does when burning TDF. However, when using TDF in a kiln which is also burning hazardous waste, especially a chlorine-laden hazardous waste, the problem of lead vapors going out the stack is very real.

The vapor pressure of lead is normally 1160 degrees F at 1×10^{-6} atmospheres (refer to the chart on page 18). Should chlorine gas be present at a 10% level, the vapor pressure goes to 5 degrees F at 1×10^{-6} ATM. Ten percent chlorine is very high; much higher than normally encountered, but it is a straight line function of the percentage of chlorine present as to the volatility of lead. Thus, the presence of chlorine in a kiln system is very important, especially if lead is also present.

CONSIDERATIONS FOR THE TEST BURN

After receiving a permit to conduct a test burn, a series of two or more short-duration test burns is normally scheduled. These tests should be designed to test conveying and feeding equipment, the effect on the kiln burning, clinker quality, and to test for any raw meal recipe changes which may be necessary. After the short term tests have been concluded and appropriate adjustments made, a long term test, 60 to 120 days, should be scheduled (the longer, the better). During this test burn, a stack test may be performed in which complete quality testing should be done. Kiln brick life should be closely observed during the long term test as well, and permitting agencies and local decision makers should be invited in to observe the project. In regard to product quality, microscope studies should be done at least daily to observe crystal size and definition, alite and belite formation, and crystal reactivity should be observed.

The calcination of the raw meal entering a kiln system occurs only when the temperature exceeds 800 degrees F, and it requires real time to occur. The 800 degrees F is argued by many, but lacking witnesses who can measure the actual temperature at that point, suffice it to say that at 800 degrees F, plus or minus 50 degrees, is the approximate temperature this occurs. Calcination is the decomposition of calcium carbonate (CaCO_3) into calcium oxide and carbon dioxide (CO_2).

Under normal circumstances, a preheater kiln may calcine 35 to 45% of the raw meal in its preheater, prior to the raw meal entering the kiln. When using TDF at 13% of the total fuel rate, the calcine rate in the preheater may increase by 25 to 30%, due to the increased heat in the fourth and third preheater stages. Thus, calcining in the preheater may go up to 45 to 56% calcined. This increase represents a large quantity of CO that does not pass through the kiln proper. This, in turn, allows space for a large increase in oxygen to go through the kiln. Therefore, if a kiln system has the fan capacity to handle additional oxygen, and if the kiln system has additional grinding capacity, and if the kiln system has the cooler capacity for additional clinker, it is possible to increase the kiln's clinker capacity while using TDF.

OTHER CONSIDERATIONS

Each time a whole scrap tire enters the kiln system at the feed end of the kiln, a CO spike occurs if the CO sample inductor is close to the feed end of the kiln. This spike occurs due to the volatility of the rubber. This rubber grabs all the available oxygen at the point of entry. There is additional oxygen present on up and down the kiln so the CO meter quickly stabilizes when the tire is being combusted. There is a time window that many environmental authorities allow wherein you may exceed the allowable CO level for a second or two, but in the preceding and following seconds, the CO must run a specific number of points below the maximum permissible CO levels to satisfy the permit conditions.

Environmental authorities are usually very anxious to run stack tests on cement kilns soon after the kiln begins using TDF. The reasons for this expedited testing schedule has no scientific or technical basis. All things being equal, it is advisable to run TDF through the kiln system for several days before beginning any testing program. The kiln system usually requires this time to become stabilized, which yields more accurate results.

The amount of time required for a kiln system to become stable varies depending upon what the process is. In the case of burning TDF, the point that requires the longest time to settle down is the injection of the heat source near the rear or feed end of the kiln instead of at the discharge end of the kiln. This action changes the heat profile at the discharge end and the feed end of the kiln. Some of the variables affected include the change of calcine rates, change in brick coating, change in kiln rings, change in the point where clinkering occurs. Each of these variables may take anywhere from three days to three weeks to stabilize.

Furthermore, settling the kiln operators into a new set of operating parameters takes, at best, one to two weeks. Thus 30 days should be the minimum amount of time a kiln is operating with TDF before any testing program begins.

SUGGESTED TESTING

The following is a suggested list of the kiln system points that should be sampled at half hour intervals throughout the entire stack test and at normal plant procedure sampling intervals for the balance of the test period. Sample points should include, at a minimum, the kiln raw meal or slurry feed, kiln dust from APCD's, both from the main and alkali by-pass units if appropriate. Clinker, pulverized coal, and coke at discharge end and at the precalciner, TDF, and hazardous waste fuel should be sampled, if being used. If some test results look suspect, more frequent sampling maybe called necessary.

During the stack testing, samples taken at the one-half hour intervals should be composited into four hour samples for testing. This is done to assure representative samples are used for testing. The various samples should be tested as noted below: kiln feed, kiln dust and clinker should be analyzed with the use of an x-ray florescence spectrophotometer for silica, aluminum, iron, calcium, magnesium, sulphur, sodium and potassium. Microscopic examination should be conducted on all composited samples throughout the TDF test burn and especially during the stack test.

Samples should also be sent to a commercial testing laboratory to test for heavy metals and for toxicity characteristic leaching procedure (TCLP), as many state environmental agencies require these data. The test for heavy metals should include arsenic, barium, cadmium, chromium, lead, mercury, selenium, and silver. It is wise to add zinc since all tires contain this element. Fossil fuels should be tested for ultimate analysis and mineral ash content plus TCLP on the heavy metals. TDF should be tested for moisture, ash, volatiles, fixed carbon, BTU, sulphur, nitrogen, hydrogen and oxygen. Each test should be run on an as received basis and a dry basis.

Furthermore, the following suggested list of parameters should be recorded during the TDF testing: raw meal or slurry feed rate, coal feed rate and percent of total fuel, coke feed rate and percent of total fuel, TDF feed rate and percent of total fuel, clinker production, dust production. The kiln shell temperature profile should be recorded hourly for six hours before the start of the test and then every four hours throughout the test to check for brick damage, coating profile changes, etc. Kiln scanners are okay but hand-held optical pyrometers at ten foot stations the length of the kiln are better. Each set of readings should be graphed. All process monitoring and their recorders should be in top working order for the entire test period. Any facility not having recorders should rent recorders for the test period. Stack opacity monitors, when not required, are also suggested.

VII.SOLID WASTE PERMIT CONSIDERATIONS

HANDLING SCRAP TIRES

For most facilities, this aspect of the permitting process should be a minimal effort, especially when using whole tires. When using whole tires, they should never hit the ground, as they should only arrive, be stored, and be fed off an enclosed trailer. Normal fire prevention/fire fighting measures can be modified to include the management of whole tire TDF. In the case of processed TDF, following the suggested procedures in the Tire Supply section should suffice for the solid waste management requirements.

TIRE SUPPLY

When you start testing, or announce your intent to do a test burn, tire suppliers will "come out of the walls." All potential suppliers should fill out a questionnaire furnished by the cement company asking questions such as: Will you use a manifest system to track scrap tires from their sources to the cement plant, complete with weights and signatures from suppliers, truckers, and cement plant personnel? Will you furnish tires in the size(s) we specify? Will you furnish clean, off rim, water-free, vermin free tires? Will you furnish tires in closed top vans? Will you take back any and all tires not in compliance with any of the above at no cost to the plant operator? What is your price FOB our plant? (Get prices on a per pound basis.) Perhaps the most significant question that has to be answered by the prospective TDF suppliers is whether they have an adequate tire supply and the appropriate state or local licenses or permits. If a supplier does not have the required documents, he should simply not be considered, regardless of his tire supplies or offering price.

Once all of these questions have been addressed by the prospective TDF suppliers, the next phase of negotiations should begin. Field experience provides us with excellent qualifying contract conditions. We suggest that the prospective supplier be required to supply a performance bond to the plant manager. This bond can be in the form of a certificate of deposit or a letter of credit or other mutually agreeable financial instrument. The two basic purposes of this requirement are to separate the pretenders from the real players and to give your organization the assurances it needs to make such a commitment.

Whole or processed TDF both require special consideration when receiving or storing them on site. Whole tires, due to their shape, can retain up to two gallons of water and are ideal breeding grounds for mosquitos and rodents. In order to avoid these potential storage problems, it is suggested that when using whole tires only, trailer load shipments be accepted. Furthermore, there should be no reason to remove the whole tires from the on-site trailers except to off-load them onto a conveyor feed system leading to the kiln. This simple management decision should alleviate the need for a solid waste management permit since no scrap tires can be dumped or loosely stored on site. Obviously, the trailer in which the whole tires are stored must be an intact,

closed top van trailer. The handling requirements for processed scrap tires is very similar to those of coal. Processed TDF can not retain water, nor does it offer any haven for mosquitos. The potential for fire is minimal, since tires will not auto-ignite until 1800°F. About the only significant management concern would be rodent infestation. However, timely pile turnover and the absence of all potential food sources in the general proximity of the pile should maintain the pile rodent-free.

A fire prevention/fire fighting plan should be devised in cooperation with the local fire department. The Council has developed guidelines for the management of scrap tire fires, which includes prevention, pre-incident planning and fire fighting tactics. The document and training course is available from the Council.

Specific routes for the trucks delivering the tires should be developed and a plan given to the drivers. The truck route should be developed such that it does not interfere with normal kiln operations.

Since the use of TDF will decrease the quantity of coal used, this change may increase the heat at the coal mill. It is important to check the cooler capacity of this system to preclude any overheating at the coal mill .

VIII.INTERNAL CONSIDERATIONS

Once the management decision has been made to test TDF, it has been found helpful to inform the employees and the public know about the TDF project. This generally helps to keep the rumors and misconceptions down to a minimum. Thus, a public relations effort is necessary. To begin the program plant employees and the public should be given a continual supply of information about what the plant's intentions are. Topics of interest will include, but are not limited to, what the goals are and how the company will accomplish these goals; what the permitting status is; what other plants are burning TDF (and how they go about it); where tires are coming from; how they are transported; the routes over which the transporters travel; and how this fuel will affect air emissions.

COMMUNICATIONS

A company spokesperson should be appointed in addition to the plant manager so that in any event, someone will be available to answer questions relating to the use of TDF. We suggest the following communication items be considered: Employee understanding --explain through memos or other standard forms of communication that the facility will soon begin testing TDF as a supplemental fuel. Points of interest should include the manner in which the TDF will be used, the fact that no black smoke will be produced and that the use of TDF will benefit both the plant (through lower fuel costs and increased productivity) and the community (by supplying a market for the scrap tires).

CUSTOMER RELATIONS

Have the sales force or management explain the technical details of TDF use to your customers. Of particular interest should be the point that the use of TDF will have no adverse effect on the quality of the cement. You may want to explain that in certain cases cement strength has improved with the use of TDF. This same point, the fact that there are no adverse effects to product quality, should also be explained to the employees.

EMPLOYEE SAFETY

One of most common misconceptions about the use of TDF is that it produces odors, black smoke, and toxic emissions. Employees may be concerned about the effects to their personal health due to the expected toxic emissions. The point that tire combustion in the kiln will not produce toxic emissions should be stressed. Data is available to clearly demonstrate that the use of TDF has actually lowered criteria emissions. It may be helpful to have the plant's union leadership contact union leaders at plants using TDF for reassurances.

PUBLIC RELATIONS

As with your employees, the public will likely have the same misconceptions (emissions, odors, and black smoke). The education of the community may be your greatest concern, but one that can be addressed effectively. There are several ways to address this issue, and hiring the services of a local, professional public relations firm is suggested. Notwithstanding this decision, there are nine items that should be considered. First, let the public know early on that you are considering the use of TDF. Two, repeat this message often. Three, hold an open house, let the public see what you intend to do. Four, answer their questions and address their concerns. Five, hand out printed material on this subject (a Q&A brochure is available from the Council). Six, send representatives to every public forum possible to communicate the benefits possible (providing a market for scrap tires --more markets mean fewer and smaller scrap tire piles. Emissions are improved, no black smoke, and that the facility is working with the state and local environmental regulatory agencies). Cost savings, while important to the plant, are usually of little concern to either the public or the regulators. Seven, publish a monthly newsletter and distribute it widely. Eight, send news releases to the local newspaper. Nine, send four or five community leaders to a plant burning tires to see how the system actually works.

PLANT OPERATIONS

Some additional points to consider when first burning TDF: When starting up a tire burning system, operators frequently overfuel with TDF. This occurs for several reasons, many of which are unknown to the operator. The primary reason is that TDF contains 1.25 times the BTU value of coal. Overfueling is detrimental to clinker quality, cools the kiln and wastes fuel.

Close attention to CO gauges may spot the problem. Another sure fire way to recognize a reducing atmosphere is to analyze the b-lite crystalline structure. A yellowish ring around the edge of the prepared crystal is the indicator for overfueling the kiln. Another consideration is overfluxing, a situation caused by too much iron. The symptom of this is a color change in the clinker

The importance in this rests on the fact that regulators frequently use CO as the ultimate measuring stick as to your ability to completely burn TDF. So, watch carefully for over firing in the first days of each kiln operator's first experience using TDF, as a reducing atmosphere will

yield high CO readings. Most regulators require a base line test prior to your TDF stack test. Try to have kiln operating conditions in your "normal" operating condition during base line tests. The following point has only arisen in cases when HWF was being burned in conjunction with TDF; however, it could occur without HWF. The presence of chlorine in the kiln or stack can cause some metals to volatilize at far lower temperatures than normally is the case. If these temperatures are present beyond the dust collection equipment, the metals leave the stack and enter the environment. This, of course, can be cause for failing a stack test if the metals escape in quantities that exceed existing regulations. The volatility of certain metals is not affected by the presence of chlorine (i.e., chromium, beryllium, barium, antimony, selenium, cadmium, arsenic and mercury). But the following chart shows some that are affected:

<u>METAL</u>	<u>VOLATILITY*</u> <u>TEMP (°F)</u>	<u>VOLATILITY TEMP* (°F)</u> <u>WITH 10% Cl</u>
Nickel	2210	1280
Silver	1660	1160
Thallium	1330	280
Lead	1160	5

*The temperature at which vapor pressure is 1×10^{-6} atm.

IX.CONCLUSIONS

This report has reviewed some of the key and more common issues raised when a facility first considers the use of TDF. From field experience we can conclude that tires can be used successfully in cement kilns, and that good quality cement can be made from the clinker generated while using scrap tires. Furthermore, production rates can be increased and fuel costs can be lowered while burning whole scrap tires. Environmental quality can be maintained using scrap tires in cement kilns. Finally, use of scrap tires in cement kilns is a viable energy recovery program.

The Scrap Tire Management Council offers technical assistance to kiln operators further explaining this material and related issues. For additional information, contact Michael Blumenthal, Executive Director, Scrap Tire Management Council, 1400 K Street, N.W., Suite 900, Washington, DC 20005.