THE RMA TCLP ASSESSMENT PROJECT: RADIAN REPORT

LEACHATE FROM TIRE SAMPLES

by

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ABSTRACT

The Rubber Manufacturers Association (RMA) authorized Radian Corporation to assess what level of chemicals, if any, are leached from representative RMA products using EPA's then proposed Toxicity Characterization Leaching Procedure (TCLP). The TCLP proposed to add chemicals to the existing list of compounds regulated under Subtitle C of the Resource Conservation and Recovery Act and to introduce a new extraction methods. The results of the TCLP study indicated that none of the tire and other rubber products tested, cured or uncured, exceeded proposed TCLP regulatory levels. Most compounds detected were found at trace levels (near method detection limits) from ten to one hundred times less than TCLP Regulatory Limits and U.S. EPA Drinking Water Standard MCL values. A comparison of the results of the EP Toxicity and TCLP procedure for RMA products indicate that the two leachate methods are comparable. Radian also compared a modification to the TCLP recently proposed by EPA that eliminates grinding prior to leaching. The results of ground and unground samples are comparable. Although the results of this study should not be extrapolated to the environment, this study provides strong evidence that leachate from scrap tire shreds/chips will not pose a threat to groundwater or surface water.

INTRODUCTION

Today, waste or scrap tires pose a substantial waste management challenge due both to the large number of tires coming off the road annually (approximately 230 - 240 million) and to the properties built into tires to insure their safety and durability in use. In total, scrap tire inventories total between 2 and 3 billion tires.

Undoubtedly, reduction of scrap tire inventories depends upon developing and enhancing markets for scrap tire rubber. Tire derived fuel and rubberized asphalt are technologies that are proven in commercial scale applications. Other uses of scrap tire shreds/chips are increasing and include road-bed fill, septic systems, embankment shoring and landfill liners, among others.

Although rubber products are thought to be relatively benign in the environment, questions have been raised as to whether certain rubber products, in particular tire shreds/chips, leach contaminants that may adversely affect the environment, specifically groundwater, surface water and wetlands. Answers to such questions provide information for legislators, regulators and industry to make competent decisions for scrap tire use in the environment.

Results of five studies suggest that leachate from tire shreds would not likely threaten the environment. Applications using whole, shredded or chipped tires for earthen embankments (DTC Laboratories, 1990), sewage disposal systems (Envirologic, Incorporated 1990) landfill applications (J&L Testing Company, 1989) and tire ponds (Environmental Consulting Laboratory, 1987) suggest that the leaching behavior does not constitute a threat to groundwater or surface water.

A study (Twin City Testing Corporation, 1990) examined leachate from tire shreds used as roadway sub-grade support in Minnesota and concluded that field studies did not identify significant differences between waste tire areas and control areas for soil samples and for the biological survey. Water samples from one site showed results in excess of the Minnesota's Recommended Allowable Limits for Drinking Water. Although the study was not conclusive, it was recommended that the use of waste tires be limited to the unsaturated zone in a roadway designed to limit infiltration of water through the waste tire subgrade.

The most conclusive laboratory study was conducted by Radian Corporation for the Rubber Manufacturers Association and is the subject of this presentation. The purpose of the study was to assess what levels, if any, contaminants may be leached from representative cured and uncured products manufactured by RMA members. Radian used the then proposed EPA Toxic Characteristic Leaching Procedure (TCLP) test procedures plus the current Extraction Procedure Toxicity (EP Tox) procedure on cured, uncured, ground and unground rubber products.

Sixteen RMA products were tested by Radian that included samples from tires, roofing products, belts/hoses, molded products, gasket/sealant and printer rollers. Because this discussion is focussed on leachate from tires, only the results of the seven products from tire manufacturers are presented. Results from the other products can be found in the RMA (1990) report by Radian Corporation and is available from the Scrap Tire Management Council or RMA.

For the study, Radian utilized the list of chemicals and methods taken from the TCLP regulations for volatile organics, semivolatile organics and metals (Appendix A). Because pesticides and herbicides are not found in member products, these listed pollutants were not included in the scope of the study. Radian also compared the results of the TCLP analysis to the results of tests on selected RMA products using the EP Toxicity Characterization protocol. A comparison between cured and uncured samples as well as ground and unground cured samples using TCLP is also presented.

In June, 1989 EPA proposed a rule intended to amend the waste characterization procedures to greatly expand the list of organic hazardous compounds by adding a volatiles extraction procedure (Zero Head Space) and by incorporating GCMS (gas chromatograph coupled with mass spectrometry) procedures for identification of both volatile and semivolatile organics. The proposed protocol was designated the TCLP (*Federal Register*, 1986) and replaces the EP Toxicity Test, includes 44 organics and 8 metals. Analytical methods used for both the EP Toxicity and newer TCLP protocols remain those in EPA's Resource Conservation and Recovery Act analytical methods manual SW846.

The TCLP, as well as the EP Toxicity protocol determines whether a waste has the potential to pose a significant hazard to human health or to the environment due to its propensity to leach toxic compounds into groundwater. A modification to the TCLP procedure was proposed by EPA (*Federal Register* 1989) that would allow certain categories of waste to undergo TCLP without being ground. This would include most RMA products.

SAMPLING AND PROCESSING OF RUBBER PRODUCTS

Radian provided participants with a detailed sampling protocol written to ensure that the samples provided to the laboratory were representative of the whole product and were not contaminated by the sampling process. The sampling protocol written by Radian ensured both a coordinated effort among the participating companies and provision of samples representative of product constituents. The manufactures that provided samples included:

- 7 - products from tire manufactures
- 1 - product from a roofing product manufacturer
- 3 - products from belt/hose manufacturers
- 3 - products from molded product manufacturers
- 1 - product from a gasket/sealant manufacturer
- 1 - product from a manufacture of printer rollers.

The tire samples provided by the 7 tire manufacturers were the following:

1 - product from a truck tire manufacturer
2 - products from light truck tire manufacturers
4 - products from passenger tire manufacturers

Radian provided participants with its SamplePak that contained collection and shipping instructions, chain-of-custody information, pre-cleaned containers and prepared labels. The instruction set included use of containers, packing, security seal use and shipping instructions. RMA participating companies provided samples of the products in sufficient quantity for TCLP ground and unground, TCLP uncured, and EP Toxicity analyses. For further information, refer to the Radian Report to the Rubber Manufacturers Association (RMA 1990).

Samples were shipped by the participants to Radian's Material Science Laboratory in Milwaukee, Wisconsin for processing. Those portions identified for the standard TCLP analysis were chopped into portions of 1 cm or less. Care was taken by Radian staff to use oil-free cutting tools and to avoid friction with the rubber material in order not to change its chemical makeup. The processed samples were shipped to Radian's facility in Austin Texas.

LEACHING METHODS

All laboratory testing was performed at Radian's facility in Austin, Texas. Laboratory operations conformed to EPA SW846 protocols for chain-of-custody, sample management and laboratory analysis. All analyses performed under EPA846 protocols applied the Third Edition methods and quality control criteria. Radian's Austin laboratory participates in the EPA WP (Water Pollution) and WS (Water Supply) performance evaluation programs and took the lead for Radian in the EPA TCLP evaluation program.

In providing an analytical approach to the TCLP analysis, absolute consistency with EPA quality assurance protocol was maintained. This required: (a) a method blank be prepared for each TCLP and EP Toxicity extraction batch; (b) the method of standard additions be used on all EP Toxicity metal analysis; and, (c) volatile and semivolatile matrix spike and matrix spike duplicates be run for batch. Radian analyzed the RMA samples for TCLP constituents and EP Toxicity constituents following procedures outlined in (a) Federal Register of June 13, 1986; (b) Method SW1310 for EP Toxicity (herbicides and pesticides were not included in the survey of compounds); and, (c) 3rd Edition protocols for laboratory analyses and quality control.

Radian used twelve Zero Headspace extractors for TCLP volatiles extraction. Two of the extractors were used for method blanks, the other ten for analysis of samples. In addition to zero headspace capacity, Radian used rotary extractors sufficient for twenty simultaneous TCLP metals and semivolatile organic leaching operations. Radian's EP Toxicity leaching capability allows for the simultaneous leaching of 15 samples by EP Toxicity protocols.

A comparison of TCLP and EP Toxicity Characterization Procedure (EP TOX) is shown in Appendix B. To leach semivolatile organics, pesticides and metals, the TCLP employs containment jar attached to a rotary tumbler spinning at a rate of 30 rpm. The volatile organics are leached in a Zero Head Space apparatus, which contains a self-enclosed piston system to force the leachate solution through a filter, effectively separating the leaching medium from the sample without exposure to air. The leaching solution for both processes is 0.1 M acetate buffer at a pH of 4.9 for non-alkaline waste and pH 2.9 for alkaline wastes.

EPA recognized that TCLP should have a test similar to the structural integrity test and proposed to use a stainless steel cage in a glass bottle to contain whole, non-viable samples during the leaching process. The purpose of the cage is to shield the glass tumbler in which the whole sample is leach from hard, rock-like wastes. Unlike vitrified or solidified waste, the rubber products being examined could not harm the tumbler when inserted as unground samples and therefore no caging apparatus was required or employed in the study.

CHEMICAL ANALYSIS

Gas chromatography combined with mass spectrometry (GCMS) employing EPA Methods SW8240 for volatile compounds and SW8270 for semivolatile constituents was used to identify the TCLP target chemicals (see Appendix B). The characteristic retention times of compounds in a GC column provided presumptive evidence of their identity. This information in conjunction with mass spectra of the compounds obtained as the elute from the GC column yielded nearly unequivocal identification of the compounds.

Radian's Inorganic Analytical Laboratories provided analyses of metals by atomic absorption spectrometers for lead, mercury and selenium analysis. Inductively Coupled Plasma Emissions Spectrometer analyzed other metals specified by EPA methods SW6010 and targeted by TCLP.

RESULTS

TCLP PROTOCOL ANALYSES OF CURED SAMPLES

The presence of TCLP metals, semivolatile and volatile organic compounds for cured, uncured and uncured/ground tire samples is shown in Table 1(a - c). Metals that were detected include arsenic (uncured), barium (cured, uncured and cured/unground), chromium (cured, uncured), lead (cured, uncured and cured/unground) and mercury (cured).

The concentration of TCLP metals detected in cured tire product samples leached and analyzed by the June 13, 1989 procedures are listed in Table 2. Barium, chromium, lead and mercury were detected in low concentrations (below both TCLP and U.S. EPA Drinking Water Standards). The U.S. EPA Drinking Water Standards are more stringent than the TCLP Regulatory Limits for metals detected:

METAL	U.S. EPA DRINKING WATER STANDARD (mg/L)	TCLP REGULATORY LIMIT (mg/L)
Barium	1.0	100.0
Chromium	0.05	5.0
Lead	0.05	5.0
Mercury	0.002	0.20

TCLP volatile and semivolatile organics detected are shown in Table 3. Carbon disulfide, methyl ethyl ketone, toluene and phenol were below TCLP regulatory standards by orders of magnitude. These organic compounds are not, as yet, regulated by U.S. EPA Drinking Water Standards.

Although constituents listed by TCLP as hazardous compounds were found in cured tire product samples, none of the values exceeded proposed TCLP regulatory levels or U.S. EPA Drinking Water Standards. Most compounds were found at trace levels from ten to one hundred times less than TCLP regulatory limits.

COMPARISON OF CURED AND UNCURED SAMPLES USING TCLP

Two cured and matching uncured samples were selected from the tire products and subjected to TCLP leaching and analysis. The comparative cured and uncured sample results are shown in Table 4 for volatile and semivolatile organics and Table 5 for metals. Similar to the values found for cured samples, TCLP leachates for uncured samples did not exceed TCLP Regulatory Limits. Methyl ethyl ketone and mercury were not detected in uncured samples. The values detected for both cured and uncured samples are comparable for cured and uncured samples.

COMPARISON OF GROUND AND UNGROUND SAMPLES

The modification of TCLP proposed on May 24, 1988 allows for TCLP leaching of unground samples. To test the effects of the proposed modification to TCLP, selected cured tire product samples underwent TCLP leaching and analysis, but without the reduction of particle size below one centimeter.

A comparative assessment of volatiles was not preformed. The proposed May 24, 1988 modifications does not address TCLP Zero Head Space Extraction for volatiles. This extraction still requires the samples to be of sufficiently small size to be placed into a compressible piston. For volatile organics, the analysis of ground "unground" samples would duplicate the initial TCLP Zero Head Space leaching process conducted for the ground samples.

Also for comparative purposes, each of the unground, cured samples selected for the study had a matching ground, cured product that had undergone TCLP. This set of products also matched the uncured products which had undergone TCLP assessment. The comparative results for the ground and unground cured samples are shown in Table 6.

As with the ground samples, only trace levels of phenol, barium and lead were found in the unground samples. It is unclear why chromium and mercury were detected in cured but not in uncured samples. Comparative differences between ground and unground samples can most likely be assigned to variances in sample constituency or analysis methods, rather than differences in the efficiency of the ground or unground approach to leaching.

COMPARISON BETWEEN TCLP AND EP TOXICITY REQUIREMENTS

A comparison of TCLP and EP Toxicity procedural requirements are shown in Appendix B. The only organics in the EP Toxicity characterization procedure are chlorinated pesticides and phenoxychlorinated herbicides, thus only results for metals are reported. Silver, arsenic, mercury and selenium were not found in the EP Toxicity leachates. The comparison of EP Toxicity leachates of cured and uncured products with the TCLP leachates of cured products showed low (trace) values for all metals except barium. Barium values were less than one percent of regulatory limits. At these trace levels, no definitive trends between EP Toxicity cured and uncured samples and TCLP leachates could be determined.

DISCUSSION

In March 1989, the Rubber Manufacturers Association (RMA) contracted Radian Corporation to determine whether cured or uncured rubber products have the potential to pose a significant hazard to human health or to the environment due to its propensity to leach toxic compounds when placed in a landfill.

Radian established a sampling protocol and analyzed various RMA products using EPA TCLP and EP Toxicity procedures on cured, uncured, ground and unground rubber products. The final report was issued in September 1990.

The results of the study indicated that none of the tire and other rubber products tested, cured or uncured, exceeded proposed TCLP Regulatory Levels or U.S. EPA Drinking Water Standards. Most compounds detected were found at trace levels (near method detection limits) from ten to one hundred times less than proposed TCLP regulatory limits.

A comparison of the results of the EP Toxicity and TCLP procedure for RMA products indicate that the two leachate methods are comparable. Chlorinated pesticides and phenoxychlorinated herbicides are the only organics in the EP Toxicity characterization procedure.

Radian compared the effect of a modification to the TCLP then proposed by EPA which would eliminate grinding prior to leaching. This modification, in effect, makes TCLP tests of rubber products more representative of disposal practice. The results inherent in ground and unground samples are comparable. Uncertainties in the TCLP procedure had a greater impact on the variability of the results than differences in ground and unground methods.

In March 1990, the EPA promulgated the Toxicity Characteristic (TC) final rule. Basically, non-listed wastes generated at a facility are to be characterized by a TCLP method differing from that in the RMA study on one major count, the need to correct data based upon matrix spike corrections. Under new rules, known amounts of TCLP compound are added (spiked) to the sample as an internal standard. The percentages of spiked compounds lost through the TCLP preparation and analysis process are then used to back-correct the concentrations of compounds found in the unspiked sample.

It is important to note that many state regulatory agencies are adapting drinking water or ground water standards to evaluate leachate from scrap tire rubber. Drinking water analytical methods attain much lower analytical detection limits than EPA SW846 methods. One rational is to prevent degradation of groundwater beyond Safe Drinking Water Act MCL levels. The appropriateness to use drinking water or ground water standards considerations needs to be examined further.

It must be kept in mind that the results of laboratory studies, such as the RMA report, should not be extrapolated to evaluate potential environmental adverse effects by scrap tire shreds/chips. It does, however, provide strong evidence that tire shreds pose no threat to groundwater and surface water. Also, the information from the laboratory studies provides the necessary background information to design a comprehensive field study to evaluate environmental effects.

Basic physical, chemical and biological processes operating in subsurface and surface environments are needed to develop methods for predicting the transport and transformation of leachate pollutants entering the subsurface. Such information are needed to assess the contamination potential of scrap tire shreds/chips. For example, hydrological processes control the flow of water and fluids through the subsurface. Contaminants moving through the subsurface may be transformed through chemical reactions, sorbed by subsurface particles or changed from a liquid to a solid state or visa versa. Abiotic transformation processes such as sorption, hydrolysis, reduction and volatilization as well as microorganisms, in particular, bacteria act to transform or facilitate transport of contaminants in the subsurface (for further information, contact EPA, Processes and Effects Research Program). Thus, subsurface process, models and methods and applied research are necessary to predict the environmental effect of leachate from scrap tires in the environment rather than simplistic laboratory studies.

Other studies suggest that the leaching behavior from scrap tire shreds does not constitute a threat to groundwater or surface water. One study (Twin City Testing Corporation, 1990) concluded that their field study did not identify significant differences between waste tire areas and control areas for soil samples and for the biological survey. Water samples at one site showed results in excess of the state Recommended Allowable Limits for drinking water while background samples did not. Thus, it was recommended that the use of waste tires be limited to the unsaturated zone in a roadway designed to limit infiltration of water through the waste tire subgrade. It was also recommended that additional field studies be performed to evaluate new or existing roadways where waste tires are used.

RECOMMENDATIONS

Questions remain concerning the effect of leachate from scrap tire products in the environment. Some pertinent questions include:

1) Which regulatory standards are appropriate to evaluate potential adverse effects on human health and environment from compounds leached from scrap tire or rubber products?

2) Are there any realistic environmental conditions/applications where scrap tires leach compounds that exceed regulatory standards?

3) Are compounds leached from scrap tire products in the environment under specific applications? If so, what is the fate of those compounds in the environment?

5) Is there an adverse effect on groundwater, surface water or wetlands from the storage or application of scrap tires?

In order to answer these questions, it is recommended that a field study be prepared in conjunction with key states (Ohio, Illinois, Pennsylvania, California, Texas, New York, New Jersey, North and South Carolina, Florida, Georgia, among others) and coordinated by the Scrap Tire Management Council. The purpose of the study may be to determine which chemical compounds and associated detection limit criteria are now reasonably required to convince the state agencies that tire disposal and its various environmental uses (roadbed fill, road shoring, septic fields, landfill liners, etc.) pose no threat to the environment. This study will likely include sampling at several existing sites to gain information as to the fate of tires and tire shreds and chips in addition to bench scale leachate and analysis studies. Properly conceived and executed, such a study would have long term applicability in addressing the effects of tire disposal and environmental use on the groundwater in different environments.

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APPENDIX A

COMPARISON OF TCLP AND EP REQUIREMENTS (Parr et al., 1987)

Contaminant	Type	Limit, mg/L TCLP Land Restriction Rule	TCLP Waste Characteristic Test	EP Toxicity (261.24)
Acetone	V	0.59	NL	NL
(Acrylonitrile)	V**	NL	5.0	NL
(Arsenic)*	M	NL	5.0	5.0
(Barium)*	M	NL	100.0	100.0
Benzene	V**	NL	0.07	NL
(Bis(2-chloroethyl) ether))	S	NL	0.05	NL
n-Butyl alcohol	V	5.0	NL	NL
(Cadmium)	M	NL	1.0	1.0
(Carbon disulfide)	V	4.81	14.4	NL
(Carbon tetra- chloride)	V	0.96	0.07	NL
Chlordane	P	NL	0.03	NL
(Chlorobenzene)	V**	0.05	1.4	NL
(Chloroform)	V**	NL	0.07	NL
(Chromium)	M	NL	5.0	5.0
Cresols (o, m, p)	S	0.75	10.0	NL
Cyclohexanone	V**	0.75	NL	NL
2,4-D	H	NL	1.4	10.0
(1,2-Dichloro- benzene)	V/S	0.125	4.3	NL
(1,4-Dichloro- benzene)	V/S	NL	10.8	NL
(1,2-Dichloroethane)	V**	NL	0.40	NL
(1,1-Dichloro- ethylene)	V**	NL	0.10	NL
(2,4 Dinitrotoluene)	S	NL	0.13	NL
Endrin	P	NL	0.003	0.020
Ethyl acetate	V**	0.75	NL	NL
Ethyl benzene	V**	0.053	NL	NL

APPENDIX A (continued)

COMPARISON OF TCLP AND EP REQUIREMENTS

Contaminant	Type	Limit, mg/L: TCLP Land Restriction Rule	TCLP Waste Characteristic Test	EP Toxicity (261.24)
Ethyl ether	V**	0.75	NL	NL
Heptachlor	P	NL	0.001	NL
Hexachlorobenzene	S	NL	0.13	NL
Hexachloro-butadiene	S	NL	0.72	NL
HxCDD (dioxins)	D	(<0.001)*	NL	NL
HxCDF (furans)	D	(<0.001)*	NL	NL
Hexachloroethane	S	NL	4.3	NL
(Isobutanol)	V**	5.0	36	NL
(Lead)	M	NL	5.0	5.0
Lindane	P	NL	0.06	0.4
(Mercury)	M	NL	0.2	0.2
Methanol	O	0.75	NL	NL
Methoxychlor	P	NL	1.4	10.0
(Methylene chloride)	V	0.96	8.6	NL
(Methyl ethyl ketone)	V	0.75	7.2	NL
Methyl isobutyl ketone	V	0.33	NL	NL
Nitrobenzene	S	0.125	0.13	NL
PeCDD (dioxins)	D	(<0.001)*	NL	NL
PeCDF (furans)	D	(<0.001)*	NL	NL
(Pentachlorophenol)	S	(<0.01)*	3.6	NL
(Phenol)	S	NL	14.4	NL
(Pyridine)	S	0.33	5.0	NL
(Selenium)	M	NL	1.0	1.0
(Silver)	M	NL	5.0	5.0
TCDD (dioxins)	D	(<0.001)*	NL	NL
TCDF (furans)	D	(<0.001)*	NL	NL

*** Effective 11/8/88; ** Not listed as volatile in method**
() TCLPs listed chemicals used in the RMA study
NL = Not listed; V = Volatile; S = Semivolatile; P = Pesticide; H = Herbicide
M = Metal; D = Dioxin; O = Other

APPENDIX A (continued)

COMPARISON OF TCLP AND EP REQUIREMENTS

Contaminant	Type	TCLP Land Restriction Rule (Limit, mg/L)	TCLP Waste Characteristic Test (Limit, mg/L)	EP Toxicity (261.24) (Limit, mg/L)
(1,1,1,2-Tetrachloro ethane)	V**	NL	10.0	NL
(1,1,2,2-Tetrachloro ethane)	V**	NL	1.3	NL
(Tetrachloro-ethylene)	V	0.05	0.1	NL
(2,3,4,6-Tetrachloro phenol)	S	(<0.10)*	1.5	NL
(Toluene)	V	0.33	14.4	NL
Toxaphene	P	NL	0.07	0.5
(1,1,1-Trichloro-ethane)	V	0.41	30.0	NL
(1,1,2-Trichloro-ethane)	V**	NL	1.2	NL
1,2,2-Trichloro-1,2,2-trifluoroethane	V**	0.96	NL	NL
(Trichloroethylene)	V	0.091	0.07	NL
Trichlorofluoro-methane	V	0.96	NL	NL
(2,4,5-Trichloro-phenol)	S	(<0.05)*	5.8	NL
(2,4,6-Trichloro-phenol)	S	(<0.05)*	0.30	NL
2,4,5-TP (Silvex)	H	NL	0.14	1.0
Vinyl Chloride	V**	NL	0.05	NL
Xylene	V	0.15	NL	NL

*** Effective 11/8/88; ** Not listed as volatile in method**
() TCLPs listed chemicals used in the RMA study
NL = Not listed; V = Volatile; S = Semivolatile; P = Pesticide; H = Herbicide
M = Metal; D = Dioxin; O = Other

APPENDIX B

A COMPARISON BETWEEN THE EXTRACTION PROCEDURE TOXICITY CHARACTERISTIC (EP TOX) AND THE TOXICITY CHARACTERISTIC LEACHING PROCEDURE (TCLP).

ITEM	EP TOX	TCLP
1. Contaminant type	14 total metals, pesticides, herbicides.	35 - 67 total metals volatile organics, semivolatile organics, pesticides, herbicides, dioxins (1988).
2. Leaching media	Distilled deionized water 0.5 N acetic acid added to leaching solution.	(1) Acetate buffer solution, pH 4.93 or (2) acetic acid solution, pH 2.88. An initial test on the waste determines which extraction fluid to be used.
3. Liquid/solid separation	0.45 μm filtration to 75 psi in 10 psi increments.	0.6 - 0.8 μm glass fiber filter filtration to 50 psi.
4. Monolithic material/ particle size	Structural Integrity Procedure (SIP) or Grinding reduction and milling.	Grinding or milling only. SIP not used.
5. Extraction vessels	Unspecified design.	Zero-headspace vessel (ZHE) for volatiles. Bottles used for non-volatiles. Blade stirrer not used.
6. Agitation	Blade/stirrer vessel acceptable or rotary end-over-end.	Rotary agitation only in an end-over-end at 30 +/- 2 rpm.
7. Extraction time	24 hours.	18 hours.

APPENDIX B (continued)

A COMPARISON BETWEEN THE EXTRACTION PROCEDURE TOXICITY CHARACTERISTIC (EP TOX) AND THE TOXICITY CHARACTERISTIC LEACHING PROCEDURE (TCLP).

ITEM	EP TOX	TCLP
8. Monitoring during	pH must be monitored by set intervals.	Not required.
9. Multiple solutions	No.	Yes; possibility of generating from single sample 2 or more solutions from the initial sample exists. Each solution is analyzed separately. Results are mathematically recombined when 2 or more phases are present.
10. Post preparation	Herbicides and pesticides only require extraction.	Metal total digestion semivolatiles, herbicides and pesticides extraction. Run volatiles directly.
11. Quality control	Standard additions required. One blank per batch.	Standard additions required in some cases. One blank per 10 extractions and every new batch of extract. Analysis specific to analyte.

Note that while EP TOX addresses only those species for which National Primary Drinking Water Standards (NIPDWS) exist, the TCLP can be applied to other toxicants.

TCLP Listed Chemicals Studied
Metals

Contaminant	Regulatory Level (mg/L)	Cured	Uncured	Cured and Unground
Arsenic	5.0		*	
Barium	100.0	*	*	*
Cadmium	1.0			
Chromium	5.0	*	*	
Lead	5.0	*	*	*
Mercury	0.20	*		
Selenium	1.0			
Silver	5.0			

* Detected

TABLE 1A

TCLP Listed Chemicals Studied
Semi-volatile Organics

Contaminant	Regulatory Level (mg/L)	Cured	Uncured	Cured and Unground
o,m,p-Cresols	10.0			
Hexachlorobenzene	0.13			
Hexachloroethane	403			
Nitrobenzene	0.13			
Pentachlorophenol	3.6	*	*	*
Phenol	14.4			
Pyridine	5.0			
2,3,4,6-Tetrachlorophenol	1.5			
2,4,5-Trichlorophenol	5.8			
2,4,6-Trichlorophenol	0.30			

* Detected

TABLE 1B

TCLP Listed Chemicals Studied
Volatile Organics

Contaminant	Regulatory Level (mg/L)	Cured	Uncured	Cured and Unground
Acrylonitrile	5.0			
Benzene	0.07			
Bis(2-chloroethyl)ether	0.05			
Carbon Disulfide	14.4	*	*	
Carbon Tetrachloride	0.07			
Chlorobenzene	1.4			
Chloroform	0.07			
1,2-Dichlorobenzene	4.3			

* Detected

TABLE 1C

TCLP Listed Chemicals
Volatile Organics

Contaminant	Regulatory Level (mg/L)	Cured	Uncured	Cured and Unground
1,1,1,2-Tetrachloroethane	10.0			
1,1,2,2-Tetrachloroethane	1.3			
Tetrachloroethylene	0.1			
Toluene	14.4	*	*	
1,1,1-Trichloroethane	30.0		*	
1,1,2-Trichloroethane	1.2			
Trichloroethylene	0.07			
Vinyl Chloride	0.05			

* Detected

TABLE 1C (continued)

TCLP Listed Chemicals
Volatile Organics

Contaminant	Regulatory Level (mg/L)	Cured	Un-cured	Cured and Unground
1,4-Dichlorobenzene	10.8			
1,2-Dichloroethane	0.40			
1,1-Dichloroethene	0.10			
2,4-Dinitrotoluene	0.13			
Hexachlorobutadiene	0.72			
Isobutanol	36.0			
Methylene Chloride	8.6			
Methyl Ethyl Ketone	7.2	*		

* Detected

TABLE 1C (continued)

Cured Tire Products - TCLP
Metals (mg/L)

Sample I.D	Barium	Chromium	Lead	Mercury
1	0.083	0.048	*	0.0002
2	0.065	0.026	0.016	*
3	0.150	0.012	0.009	*
4	*	0.035	0.014	*
5	0.570	0.037	0.002	0.0004
6	0.590	0.025	0.002	*
7	0.021	0.047	0.016	*
Reg. Limit	100	5.0	5.0	0.2
MDL	0.01	0.01	0.002	0.0002

* Metals not detected or detected below method detection limits
MDL = Minimum Detection Limits

TABLE 2

Cured Tire Products - TCLP
Volatile and Semi-volatile Organics (mg/L)

Sample I.D	Carbon Disulfide	Methyl Ethyl Ketone	Toluene	Phenol
1	0.034	*	0.011	0.013
2	0.035	*	0.007	0.010
3	0.067	0.021	0.050	*
4	0.017	*	0.010	0.022
5	*	*	0.190	0.046
6	*	*	*	0.045
7	*	*	0.020	*
Reg. Limit	14.4	7.2	14.4	14.4
MDL	0.005	0.1	0.005	0.01

* Compounds not detected or detected below method detection limits
MDL = Minimum Detection Limits

TABLE 3

Cured and Uncured Tire Products - TCLP
Volatile and Semi-Volatile Organics (mg/L)

Sample I.D	Carbon Disulfide	Methyl Ethyl Ketone	Toluene	Phenol
3a	0.067	0.021	0.050	*
3b	0.012	*	0.017	*
5a	*	*	0.190	0.046
5b	*	*	0.120	0.050
Reg. Limit	14.4	7.2	14.4	14.4
MDL	0.005	0.1	0.005	0.01

* Compounds not detected or detected below method detection limits
a = TCLP (cured); b = TCLP (uncured); MDL = Minium Detection Limit

TABLE 4

Cured and Uncured Tire Products - TCLP Metals (mg/L)

Sample I.D	Arsenic	Barium	Chromium	Lead	Mercury
3a	*	0.150	0.012	0.009	*
3b	*	0.072	0.023	0.008	*
5a	*	0.570	*	*	0.0004
5b	0.002	0.036	0.025	0.005	*
Reg. Limit	5.0	100.0	5.0	5.0	0.20
MDL	0.001	0.01	0.01	0.002	0.0002

* Metals not detected or detected below method detection limits
a = TCLP (cured); b = TCLP (uncured); MDL = Minimum Detection Limits
TABLE 5

Cured and Uncured Tire Products - TCLP Semi-volatiles and Metals (mg/L)

Sample I.D	Phenol	Barium	Chromium	Lead	Mercury
3a	*	0.150	0.012	0.009	*
3b	0.040	0.140	*	0.010	*
5a	0.046	0.570	0.037	*	0.0004
5b	0.050	0.020	*	*	*
Reg. Limit	14.4	100	5.0	5.0	0.20
MDL	0.01	0.01	0.01	0.002	0.0002

* Metals not detected or detected below method detection limits
a = TCLP (cured); b = TCLP (unground, cured); MDL = Minimum Detection Limits
TABLE 6

TCPL and EP Toxicity - Cured and Uncured Samples
Metals (mg/L)

Sample I.D	Barium	Chromium	Lead	Mercury
3a	0.150	0.012	0.009	*
3d	0.073	*	0.016	*
3e	0.041	*	0.03	*
5a	0.570	0.037	0.002	0.0004
5d	*	*	0.005	*
5e	*	*	0.004	*
Reg. Limit	100	5.0	5.0	0.20
MDL	0.01	0.01	0.002	0.0002

* Metals not detected or detected below method detection limits
a = TCLP (cured); d = EP Tox (cured); e = EP Tox (uncured)

TABLE 7