Guidance Manual

SHREDDED TIRES AS ALTERNATIVE DAILY COVER AT MUNICIPAL SOLID WASTE LANDFILLS

California Integrated Waste Management Board
Sacramento, California

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DISCLAIMER

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1. INTRODUCTION

1.1 Term of Reference

This Guidance Manual has been prepared by GeoSyntec Consultants, Inc., of Walnut Creek, California, for the California Integrated Waste Management Board (CIWMB). The manual provides a summary of recommended procedures for use of tire shreds as alternative daily cover (ADC) material at municipal solid waste (MSW) landfills.

The manual was prepared by technical staff of GeoSyntec Consultants under the supervision of Mr. Krzysztof S. Jesionek, P.E. The manual was reviewed by Dr. Dana N. Humphrey, P.E., of the University of Maine and Dr. R. Jeffrey Dunn, P.E., G.E., of GeoSyntec Consultants.

1.2 Program Overview

Over 250 million scrap tires are generated annually in the United States with California accounting for an estimated 30 million of this total. Tires have historically represented a significant solid waste management and disposal problem, as evidenced by large stockpiles that have become public health hazards and liabilities. In response to this continuing problem, the CIWMB has initiated a program to define, document, and develop major applications for the use of scrap tires. Numerous civil engineering applications, including those for construction, operations, and closure of MSW landfills, have been identified. The identified MSW landfill applications include use of tire shreds for: (i) alternative daily cover (ADC); (ii) foundation layer of a final cover system; (iii) landfill gas collection layer; (iv) operations (protection) layer; and (v) a leachate collection drainage layer. This report describes the process of using the tire shreds as an ADC material. Separate guidance manuals are being prepared for each of the other landfill applications.

General guidance on regulatory aspects of ADC will be provided by the CIWMB in an upcoming Enforcement Agency (EA) advisory.

1.3 What Are Waste and Scrap Tires and Tire Shreds?

According to the American Society of Testing and Materials (ASTM) [1997c], a "waste tire" is defined as a tire, which is no longer capable of being used for its original purpose, but which has been disposed of in such a manner that it can not be used for any other purpose. A "scrap tire" is a tire, which can no longer be used for its original purpose due to wear or damage. "Tire shreds" are pieces of scrap tires that have a basic geometrical shape and are generally between 50 mm (2 in.) and 300 mm (12 in.) in size. (Since tire shreds used as ADC are generally produced from tires, which can no longer be used for their original purpose, they will be referred to as "scrap tires" rather than "waste tires".) The reduction in tire size is commonly accomplished by a mechanical processing device called a "shredder". Tires retain their basic chemical properties and physical shape even when shredded into smaller pieces.

1.4 Purpose of Guidance Manual

This manual has been compiled to guide the landfill owner/operator through the process of incorporating the use of tire shreds as landfill ADC material. This manual may be referred to for information regarding applicable regulatory requirements related to ADC, permitting, storage and handling, and placement of the tire shreds as ADC. Any facility-specific concerns or questions regarding this manual should be directed to the Enforcement Agency (EA) having a jurisdiction over the landfill.

1.5 Guidance Manual Organization

The remainder of this guidance manual is organized as follows.

- A summary of regulatory requirements related to the use of tire shreds as ADC material is presented in Section 2.

- A summary of performance criteria for ADC materials and performance evaluation of tire shreds as ADC is presented in Section 3.

- A summary of tire shred characteristics, as they relate to use as ADC, is presented in Section 4.

- A procedure for using tire shreds as ADC material is presented in Section 5.
- A list of references cited in the manual is included in Section 6.
- Limitations on the application of information presented in this manual are described in Section 7.

2. REGULATORY REQUIREMENTS

2.1 Federal Requirements

Federal requirements for ADC at MSW landfills are contained in Part 258 of Title 40 of the Code of Federal Regulations. These requirements, often referred to as Subtitle D, were promulgated on 9 October 1991. Many of the provisions of Subtitle D, including the provisions for daily cover, took effect on 9 October 1993. The federal requirements allow the owner or operator of a facility to apply for ADC to be used at a landfill. §258.21(b) of Subtitle D states that:

> *"Alternative materials of an alternative thickness (other than at least six inches of earthen material) may be approved by the Director of an approved State if the owner or operator demonstrates that the alternative material and thickness control disease vectors, fires, odors, blowing litter, and scavenging without presenting a threat to human health and the environment."*

2.2 State Requirements

State requirements related to ADC are included in Title 27 of the California Code of Regulations (CCR). Section 20670 of Title 27 authorizes the Enforcement Agency (EA) to prescribe the quality, quantity, and methodology employed in the application of daily cover at MSW landfills.

Section 20164 of Title 27 of the CCR defines daily cover material as *"... that cover material placed on the entire surface of the active face at least at the end of each operating day in order to control vectors, fire, odor, blowing litter and scavenging."* Further, ADC is defined as *"... cover material other than at least six inches of earthen material, placed on the surface of the active face at the end of each operating day to control vectors, fires, odors, blowing litter and scavenging."*

Section 20680(c) of Title 27 of the CCR, consistent with 40 CFR §258, states that "*Demonstration of alternative materials of alternative thickness (other than at least six* *inches of earthen material) for MSWLF units may be approved by the EA. If the owner or operator demonstrates that the alternative material and thickness control vectors, fires, odors, blowing litter, and scavenging without presenting a threat to human health and the environment, the EA jointly with the CIWMB may grant final approvals of the usage of alternative materials."*

Tire shreds used as ADC are regulated by proposed Section 20690 of Title 27 of the CCR, which states that:

"*(A) Shredded tires used as daily cover alone or mixed with soil shall be shredded such that 50% by volume is smaller than 6 inches in length and no individual pieces are greater than 12 inches in length.*

(B) Shredded tires used as alternative daily cover without admixed soil shall not be applied when there is precipitation or when there is a local forecast or greater than 40% chance of precipitation within 8 hours of application time in the vicinity of the landfill."

Storage and processing of tires at a facility is regulated in accordance with Sections 17350 through 17356 of Article 5.5, Chapter 3, Division 7, Title 14 of the CCR and Section 18420(a)(1), Article 1, Chapter 6, Title 14 of the CCR. In particular, Section 17353(a) of Title 14 requires that "*All waste tires shall be stored in a manner which prevents the breeding and harborage of mosquitoes, rodents, and other vectors..."*

Section 17354(a) of Title 14 of the CCR requires that *"... waste tires shall be restricted to individual tire storage units that do not exceed 5000 square feet of contiguous area. Any pile shall not exceed 50,000 cubic feet in volume nor 10 feet in height... Waste tires shall not be located within 10 feet of any property line*."

3. PERFORMANCE CRITERIA

3.1 General

To evaluate the general suitabililty of the use of tire shreds as an ADC at MSW landfills, performance criteria for this application were developed [GeoSyntec, 1994]. Assessment of the performance criteria has indicated that tire shreds are compatible with waste and, if used appropriately, are generally acceptable for use as ADC. There are, however, limitations to the use of tire shreds as ADC, which should be evaluated on a site specific basis. These limitations have been incorporated into the assessment of the performance criteria.

3.2 Performance Criteria for ADC

The following criteria should be evaluated on a site-specific basis to evaluate suitability of tire shreds as ADC at the facility:

- protection of public health including:

- controls vectors
- controls landfill gas
- does not sustain breeding environment
- contains no toxic materials
- odorless
- contains no pathogens;

- protection of environment including:

- controls dust
- controls litter
- controls odors
- controls fires
- does not contribute to leachate generation
- does not contribute organics/inorganics to leachate or runoff

- controls erosion of waste due to water
- does not contribute to hazardous airborne dust or fumes;

- durability including:

- resistance to burrowing from birds and rodents
- erosion resistance to wind
- erosion resistance to water
- decomposition within refuse (biodegradable)
- working life of a single application
- puncture/tear resistance;

- operational impact including:

- storage space requirements
- handling equipment requirements
- labor requirements
- trafficability and support requirements
- compaction requirements
- ability to be graded
- coverage rate
    - installation during adverse weather conditions (hot and freezing temperatures, high winds, moderate and maximum rain intensity);

- product characteristics including:

- limits movement of oxygen into waste
    - physical and chemical compatibility between various cover system components
- source of nutrients for animals
- aesthetics
- flexibility (ductility to accommodate differential settlement)
- compressibility
- flammability
- allows migration of leachate and gas within refuse

    - resistance to adverse weather conditions after deployment or hardening (hot and freezing temperatures, high winds, moderate and maximum rain intensity);
- high field capacity;

- cost impact including:
- availability
- efficient utilization of landfill airspace
- cost; and

- engineering performance including:
- slope stability
- improves landfill stabilization.

The acceptance of scrap tires as ADC material depends on the material's performance with respect to the above listed applicable criteria.

3.3 Tire Shreds Performance Evaluation

3.3.1 General

A performance evaluation for tire shreds as ADC material was completed based on: (i) experience to date from a demonstration project at the Chicago Grade Landfill near Atascadero, California; (ii) literature review; and (iii) discussions with landfill owners and airborne dust or fumes.

Waste disposed of at MSW landfills includes paper, plastic, rags, and other light compatible with MSW and if used appropriately, can generally meet performance criteria for ADC material at MSW landfills. The performance of scrap tire shreds as ADC material is site-specific and, therefore, the product's performance evaluation should be conducted for each landfill site. A brief description of a general tire shreds ADC performance evaluation follows.

3.3.2 Protection of Public Health

Generally, tire shreds when used properly as ADC material (see Section 5 of this manual) will provide protection of public health by controlling vectors, not sustaining a breeding environment, being free of toxic materials, being odorless, and not containing pathogens. However, this material may not effectively control landfill gas.

3.3.3 Protection of Environment

Generally, tire shreds when used as ADC material will provide protection of the environment by adequately controlling dust, litter and odor, not contributing to leachate generation, not contributing organics or inorganics to leachate or surface run-off [Humphrey et al, 1997], controlling erosion of waste, and not contributing to hazardous airborne dust or fumes.

Waste disposed of at MSW landfills includes paper, plastic, rags, and other light weight material that may be picked up and carried away by the wind. Tire shreds ADC will control blowing litter by keeping waste in place and protecting it from the wind. Some soil, ash, and other fine-sized waste disposed of at solid waste landfills may create dust-related problems during high winds. Tire shreds ADC controls dust by protecting such wastes from being dispersed by the wind. Decaying organic waste in MSW landfills produces foul odors that may escape to the atmosphere from the uncovered surface of the waste. Section 17683 (b)(1) of Title 14 of the CCR requires that "*The operator shall not cause... the ambient air at or beyond the facility's property boundary to be odorous*...". Tire shreds should control odors by preventing them from escaping to the atmosphere. The facility owner/operator should monitor any odor problems at or beyond the landfill's boundary when tire shreds are used as ADC material. In case of odor detection, it is recommended that a mixture of earthen material and tire shreds, at a rate of at least 50% soil based on bulk (total) volume of the mixture, be used as ADC to mitigate the problem.

ADC tire shreds, due to their physical characteristics, will not control infiltration of water into the refuse and will not control landfill fires. Therefore, this material should not be used for daily cover during wet weather or, as a preventive measure, also should not be used when rain is expected. However, if the landfill is designed as a "bioreactor", where leachate recirculation is enhanced to increase the refuse decomposition rate and increased infiltration, tire shreds might then be used during rainy periods as well. A more permeable daily cover material such as tire shreds will probably allow leachate within the waste mass to reach the leachate collection and recovery system (LCRS) more quickly than some soil or other ADC materials. Tire shreds, due to their chemical composition, are combustible and thus will not minimize potential fire hazard.

The tire shreds can be mixed with soil prior to placement over the working face to mitigate the potential for fire hazard or reduce potential for rainfall infiltration. If ADC consisting only of tire shreds is used, as a precaution against the spread of a fire through the waste at a landfill, earthen material (without tire shreds) should be used as daily cover at least once a week.

3.3.4 Durability

Generally, tire shreds or tire shreds mixed with soil when used as ADC material will provide adequate cover durability by providing resistance to burrowing from birds and rodents and erosion resistance to wind and water. This is because of the large size of the tire shreds and the steel belts, which protrude from the cut edges of the shreds. The protruding steel belts tend to interlock when the tire shred layer is compacted producing a stable mass. However, the tire shreds will not biodegrade (i.e., will not decompose along with refuse) [Goehrig, 1996].

3.3.5 Operational Impact

There are a number of operational issues related to the tire shreds ADC. Production of tire shreds requires specialized shredding equipment and additional personnel. Handling, trafficability, and storage requirements are comparable to soil requirements. Deployment of tire shreds ADC material during adverse weather conditions is apparently easier when compared to earthen material based daily cover. Tire shreds can be a hazard to personnel walking on the tire shreds. Tire shred metal wires can cause flats in site vehicle tires. Thus, track mounted or steel wheeled equipment should be used to mitigate this problem. Tire shreds are relatively easy to place and grade over waste on slopes 3 horizontal to 1 vertical (3H:1V) or flatter. However, tire shreds with excessive amount of long, exposed steel belt can be difficult to spread. The shreds are difficult to compact, as are some soils, especially over waste. Due to their high permeability, the shreds usually should not be used during wet weather. The ADC shreds should not contribute significantly to decreases in slope stability.

Producing the mixture of tire shreds and soil do pose some operational concerns by adding an additional material preparation step. Further, the mixture tends to segregate during handling and placement.

3.3.6 Product Characteristics

Tire shreds have properties that will generally render them suitable for ADC material. These properties include:

- material flexibility to accommodate differential settlement within the landfill mass;

- not providing a source of nutrients for animals:

- high permeability to allow migration of leachate and gas within refuse; and

- resistance to adverse weather conditions (i.e., high wind, hot and freezing temperatures).

However, some other properties of the tire shreds are not desirable for ADC material. These properties include:

- combustibility (thus not minimizing the potential for fire hazard); and

- high permeability (thus not minimizing water infiltration).

The potential for concern over these adverse properties varies, based on the environmental conditions at a particular site. Therefore, tire shreds should be used with some site-specific restrictions as discussed previously.

The undesirable characteristics of combustibility and high permeability are applicable only to tire shreds used alone (i.e., not mixed with soil). The combustibility of a 50% - 50% mixture (by weight) of tire shreds and soil is expected to be low. Moreover, laboratory tests show that mixtures with more than 30% to 50% soil (by weight) have a hydraulic conductivity that is similar to that of the soil. Although tire shreds alone would allow oxygen to move into the waste, mixtures of tire shreds and soil would be expected to have performance similar to soil. Tire shreds used alone would have a small field capacity; however, the field capacity would be expected to increase as more soil is mixed with the shreds.

3.3.7 Cost Impact

Section 17355(a) of Title 14 of the CCR states that "*After January 1, 1993, waste tires may not be landfilled in a solid waste disposal facility...*". Therefore, shredding the scrap tires and using them as ADC material efficiently utilizes the resource and landfill airspace. Since more than 250 million scrap tires are discarded in the United States each year [Narejo and Shettima, 1995], the availability of the material is generally high.

Using tire shreds as ADC material has been found to generally be cost effective compared to soil, despite additional equipment and labor requirements to shred the tires. Tipping fees may be received for accepting tires, volume reductions from shredding the tires extend landfill capacity, and additional costs are reduced due to a decrease in required soil. However, cost effectiveness should be evaluated on a site by site basis as the local availability of scrap tires and cost of soil will vary.

3.3.8 Engineering Performance

Tire shreds, when used as ADC material, should not significantly impact engineering performance of the landfill. Available published data on shear strength of tire shreds indicates a wide range of shear strength properties for tire shreds and tire shred/soil mixtures. The data are from varying test types and test conditions [Bressette, 1984; Edil and Bosscher, 1992; Humphrey et al., 1993; Ahmed, 1993; Humphrey and Sandford, 1993; Benda, 1995; Benson and Khire, 1995; Cosgrove, 1995]. The range of values indicate that tire shreds and tire shreds/soil mixtures have shear strengths at least comparable to typical values of MSW. Therefore, the use of tire shreds should not have a detrimental effect on waste mass stability.

4. MATERIAL CHARACTERISTICS

4.1 General

For the purpose of this manual, the material characteristics of shredded scrap tires have been divided into two categories: (i) general tire and tire shred characteristics; and (ii) engineering properties of tire shreds. The general characteristics include the material composition of the scrap tires, which are most commonly encountered. Engineering properties include the results of laboratory testing on tire shreds and a mixture of tire shreds and soil. It is recommended that prior to the use of tire shreds as ADC, this section be reviewed to evaluate whether or not the ADC material being considered is compatible with the existing environmental and operating conditions at a particular landfill site.

4.2 General Tire and Tire Shred Characteristics

Modern tires are composed of a combination of natural rubber and synthetic rubber elastomers derived from oil and gas. Multiple carbon blacks, extender oils, waxes, antioxidants and other materials are added to enhance performance characteristics and manufacturing efficiency. Different polymers and additives are generally utilized in each section of a tire to optimize performance characteristics. Due to the composition and curing process, tires retain their basic chemical properties and physical shape even when shredded into smaller pieces [Gray, 1997].

Unless the tires are very old, steel and/or fabric reinforcement will have been added to improve strength, especially in the bead area bordering the rim. Steel belts and beads in the tire shreds (up to several inches or more in length) can be exposed. These can be dangerous to both equipment and personnel.

Dissolution of exposed steel (iron) and zinc oxide can occur in aqueous environments depending upon pH conditions. Some initial studies indicate that trace quantities of organic compounds and metals can also be leached from tires when continuously submerged in water under acidic or basic conditions outside of the range normally encountered in nature [Gray, 1997; Humphrey et al.,, 1997]. Tire shreds may otherwise be considered virtually non-biodegradable.

Although tire composition varies by manufacturer and type, the predominant inorganic constituents include: (i) steel from reinforcing wire representing 5% - 15% of total weight; (ii) titanium dioxide used in white sidewalls and raised letters; and (iii) zinc oxide and sulfur distributed uniformly within the polymer matrix to achieve vulcanization. Smaller concentrations of calcium and aluminum are present, along with traces of magnesium, phosphorus, potassium, silica, sodium and chloride [Gray, 1997].

Whole and shredded tires have a flash point in excess of 580☜F (322°C), meaning that tires are flammable if exposed to a continuous source of ingnition capable of generating such temperatures. Although a lighter or cigarette can ignite a localized tire surface, continuing combustion generally requires another fuel source to provide sustained high temperature exposure [Gray, 1997]. Past experience has shown that self-ignited fires of tire shreds most commonly occur in thick fills (at least 20 ft (6 m) deep) [Humphrey, 1996a].

4.3 Engineering Properties of Tire Shreds

Laboratory testing on tire shreds has been performed in both the public and private sector for various purposes. Only those properties applicable to the use of tire shreds as ADC material are discussed herein. Physical characteristics of tire shreds are dependant upon the shred size (gradation), uniformity, and exposed wire content. Tests have also been conducted on tire shreds mixed with soil.

4.3.1 Specific Gravity

The specific gravity of tire shreds is the ratio of unit weight of solids of the shreds divided by the unit weight of water. (A material, whose unit weight of solids equals the unit weight of water, has a specific gravity of 1.0.) The specific gravity is evaluated in accordance with ASTM C 127 [ASTM, 1997a]. (Note, that the specific gravity of tire shreds is usually less than half the values obtained from common earthern materials usually tested by this method, so it it permissible to use a minimum weight of test sample that is half of the specified value [Humphrey, 1996b].)

The apparent specific gravities of tire shreds, depend on the amount of glass belting or steel wire in the tire, and range from 1.02 to 1.27, meaning that tire shreds are heavier than water and will sink in water. (The high end of the range generally have a greater proportion of steel belted shreds.) For comparison, the specific gravity for soil typically ranges between 2.6 to 2.8, which is more than twice as heavy as tire shreds [Humphrey, 1996b].

4.3.2 Water Absorption

Absorption capacity is the amount of water absorbed onto the surface of the tire shreds and is expressed as the percent (%) water (based on the dry weight of the shreds). Water absorption capacity of tire shreds generally ranges from 2% to 4.3% [Humphrey, 1997].

4.3.3 Gradation

Tire shreds are generally relatively uniformly graded (i.e., mostly the same size). Sizes of tire shreds are determined based on an anticipated application of this material. The whole tires are cut by shredder knives. The required size is achieved by adjusting the screen size on a slow rotating shredder screen (i.e., trommel). Typically, multiple passes through the shredder are required for tire shred sizes of less than 12 in. (305 mm).

The gradation of tire shreds is evaluated in accordance with ASTM D 422 [ASTM, 1997b). The sample size should be large enough to contain a representative selection of particle sizes. (Note, that since the specific gravity of tire shreds is usually less than half the values obtained from common earthern materials usually tested by this method, it it permissible to use a minimum weight of test sample that is half of the specified value [Humphrey, 1996b].)

4.3.4 Compacted Unit Weight

Evaluation of the compaction characteristics of tire shreds is useful in determining the compactive effort required to achieve a workable material density. Previous studies have shown that compactive energy has only a small effect on the resulting dry unit weight. This indicates that the maximum dry unit weight can be achieved with only a moderate amount of compactive energy. Moreover, water content has been shown to have only a small effect on compacted unit weight [Manion and Humphrey, 1992].

Loosely dumped tire shreds typically exhibits dry density between 21 and 31 lb/ft^3 (3.3 to 4.8 kN/m^3), wheras compacted material typically exhibits dry densities between 38 and 43 lb/ft^3 (5.9 to 6.7 kN/m^3) [Humphrey, 1997]. For comparison, the compacted dry unit weight of soils typically ranges between 100 and 125 lb/ft^3 (15.6 and 19.5 kN/m^3), thus about 60% less than the dry unit weight for soil.

The (laboratory) compacted unit weights of a mixture of tire shreds and soil indicate, as expected, that the more soil in the mixture, the higher the unit weight.

4.3.5 Compressibility

The compressibility of tire shreds is applicable in evaluating landfill airspace. Previous tests on tire shreds less than 3-in. (75-mm) in size indicate that vertical strains of up to approximately 25% may occur in the tire shreds under low vertical stress of up to approximately 7 lbf/in^2 (48 kPa) [Nickels, 1995] and that vertical strains of up to approximately 40% may occur under high vertical stress of up to 60 lbf/in^2 (414 kPa) [Manion and Humphrey, 1992].

4.3.6 Shear Strength

Tire shreds placed as distinctive layers within a MSW landfill could influence the internal stability of the landfill. As discussed in Section 3.3.8, shear strengths of tire shreds and tire shred/soil mixtures are variable. However, it appears that they have shear strength properties such that no detrimental effect on landfill stability should occur.

4.3.7 Hydraulic Conductivity

Evaluation of the hydraulic conductivity of tire shreds is needed for assessing their performance when used at a MSW landfill. Various tests have indicated the hydraulic conductivity of 0.5 to 3-in. (12 to 75-mm) size tire shreds to be on the order of 0.6 to 24 cm/s [Humphrey, 1997]. These high values of hydraulic conductivity suggest that tire shreds when used as ADC material: (i) will not impede the infiltration of water into the waste; and (ii) will allow leachate to reach the leachate collection and recovery system

(LCRS) more quickly as compared to a typical soil. The range in values of hydraulic conductivity may be due to differences in shred size, initial density, hydraulic gradients, and confining pressures under study conditions [Donovan et al., 1996; Humphrey, 1996b].

The hydraulic conductivity of a mixture of tire shreds and soil greatly depends on the percentage of soil in the mix, shred size, initial density, hydraulic gradients, soil type, and confining pressures. The hydraulic conductivity decreases significantly as the percent soil in the mix increases. For mixtures of tire shreds and soil, with 30% to 50% soil by weight, hydraulic conductivities approach those of the soil itself.

4.3.8 Environmental Considerations

Tire shreds are considered by the State of Califrornia to be non-hazardous material [CRWQCB, 1988]. A number of leachability tests were performed on tire shreds using both tap water and landfill leachate. The results of these tests indicate that tire shreds do not leach volatile organic compounds (VOCs) or, when leaching does occur, these compounds are found at very low concentrations, i.e., below the primary drinking water standards or action levels. Additionally, these same tests indicate that concentrations of tested metals were below their primary or secondary drinking water standards with the exception of iron and manganese [Duffy, 1996; Humphrey, 1996b; Humphrey et al., 1997]. The source of the manganese is thought to be the exposed steel belts, which are composed of 2% to 3% manganese by weight. Further, it has also been shown that iron leaches more rapidly in below ground-water table applications than in above ground-water table applications. Laboratory studies suggest that metals leach more readily under acidic conditions and organic compounds leach more readily under basic conditions [Minnesota Pollution Control Agency, 1990]. The source of the zinc may be zinc oxide in the rubber or the zinc in the coating on the bead and belt wires [Humphrey et al., 1997].

5. GUIDANCE FOR USING TIRE SHREDS AS ADC MATERIAL

5.1 General

This section describes recommended procedures to be followed by MSW landfill owners/operators who consider using tire shreds as ADC material. The procedures include the following activities:

- permitting;
- acquisition of whole tires or tire shreds;
- storing of whole tires and tire shreds;
- tire shred sizing;
- mixing of tire shreds with soil, optional;
- placing of tire shreds;
- monitoring;
- documenting; and
- health and safety.

The recommendations have been develeoped for the most part on only one (at the time of this manual preparation) demonstration project, which is underway in California. Information from the project was supplemented by a literature review and conversations with landfill owners/operators who have used tire shreds at their landfills although not necessary as ADC material. Tire shred specifications define the physical characteristics of the material for use as ADC, as well as the required site and operating conditions.

5.2 Permitting

Use of tire shreds as ADC material at MSW landfills is encouraged, where appropriate, by the CIWMB. Therefore, it is anticipated that, if these recommendations are followed, the approval process will be streamlined and will not require extensive time and resources by the landfill owner/operator.

It is recommended, therefore, that as the first step in the permitting process, the owner/operator of a MSW landfill issue a letter of intent to use tire shreds as ADC material and to apply for modification of the Solid Waste Facility Permit to incorporate the use of tire shreds for daily cover.

The following regulatory agencies will have to provide approval prior to implementing the program of using tire shreds as ADC material:

- local Enforcement Agency (EA);
- local fire department;
- California Integrated Waste Management Board;
- California Regional Water Quality Control Board; and
- Air Quality Management District.

This list includes only those approvals, which are required at the time of preparing this manual, i.e., October 1997. Additional permits or approvals may be required, based on facility location and controlling local agency regulations. Local regulatory agencies should also be contacted regarding additional requirements.

General guidance on regulatory aspects of ADC will be provided by the CIWMB in an upcoming EA advisory.

5.3 General Material Characteristics

The ADC material should be made from scrap tires shredded into the size range specified in Section 5.7. The tire shreds should be free of any surface contaminants such as oil, grease, petroleum hydrocarbons (i.e., diesel fuel, gasoline), etc., that could create a fire hazard. In no case shall the tire shreds contain the remains of tires that have been subjected to a fire because the heat of a fire may liberate liquid petroleum products (i.e., pyrolytic oil) from the tire shreds that could create an increase fire hazard or contribute to leachate generation when the shreds are placed in the landfill. Since "U-shaped" pieces would affect the ability of the ADC layer to meet performance criteria, at least one tire side wall shall be severed from each piece.

5.4 Equipment and Labor Requirements

Initial activities are required prior to the use of shredded scrap tires as ADC. These include preparation of sufficient storage area, obtaining the necessary equipment to handle, process, and place the ADC material, and assigning and training of the necessary personnel.

Tire shreds can either be purchased and delivered to the landfill site or whole scrap tires, delivered to the site, can be shredded on-site. In order to allow greater control of the size and quality of the shreds, it is suggested that the whole tires be delivered to site, stockpiled, and shredded on-site.

A slow-rotating shredder cutter can be used to produce the shreds. A wood chipper should not be used. Various types of shredders, including sawtooth-type or hook-type shredder cutters, are available from different manufacturers. In the past, hammer mills have been used for shredding, however, this is not considered acceptable for ADC material processing, as a hammer mill produces an excessive amount of exposed steel belts and beads.

Because of the hazards associated with shredded tires and exposed steel belts and beads, it is suggested that track-mounted equipment, if feasible, be used on and around the tire shreds. Tire shreds may be placed over the working face using landfill equipment such as dozers or steel-wheeled compactors with blades.

If the shreds are produced on site, at least two personnel are required for the shredding process. These personnel must be trained to use the shredder prior to implementation and should be warned of the hazards posed by the steel belts and beads. Appropriate personal protective equipment, including protective work clothing and stiff-soled shoes with a steel insert and steel toes, should be utilized by personnel during shredding and placement activities.

5.5 Storage of Whole Tires and Tire Shreds

5.5.1 Whole Tires

Whole scrap tires delivered to a MSW landfill site, for the purpose of being shredded and used as ADC material, shall be stored in a manner which prevents the breeding and harborage of mosquitoes, rodents, and other vectors. The whole scrap tires shall be restricted to individual tire storage units that do not exceed 5,000 ft^2 (465 m^2) of contiguous area. Any pile shall not exceed 50,000 ft^3 (38,250 m^3) in volume nor 10 ft (3 m) in height. Tire storage units shall not exceed 6 ft (1.8 m) in height when within 20 ft (6 m) of any property line. Stockpiled scrap tires shall not be located within 10 ft (3 m) of any property line. Scrap tires shall be separated from vegetation and other potentially flammable materials by no less than 40 ft (12 m). The minimum distance between scrap tires and structures that are located either on-site or off-site shall be as specified in Section 17354 of Title 14 of the CCR. Additionally, any landfill storing 500 or more scrap tires outdoors must comply with the technical and operational standards in Sections 17351 through 17355 of Article 5.5, Title 14 of the CCR.

Sections 17351 (Fire Prevention Measures) and 17354 (Storage of Waste Tires) of Title 14 also authorize the local fir authority to require alternative site-specific requirements for a facility.

5.5.2 Tire Shreds

Tire shreds shall be subject to the whole tire storage requirements described in Section 5.5.1. Due to combustibility of tire shreds, it is recommended that only the tire shreds to be used that day as ADC material shall be transported and stockpiled next to the working face.

5.6 <u>Metal Wires</u>

Metal wires need not be removed from the tire shreds. However, they shall protrude no more than 1 in. (25 mm) from the cut edge of the tire shred on 50% of the pieces and no more than 2 in. (50 mm) on 90% of the pieces. Since protruding metal wires may injure personnel or cause flat tires in rubber-tired equipment, tire shreds should be handled appropriately.

5.7 <u>Size of Tire Shreds</u>

Tire shreds, used as ADC material at MSW landfills, shall have a maximum dimension, measured in any direction, of 12 in. (305 mm) and at least one side wall shall be severed from each piece (i.e., no "U-shaped" pieces allowed). Further, the tire shreds used as ADC alone or mixed with soil shall conform to the following schedule (Table 1):

Table 1
Tire Shred Size Requirement

Sieve Size(1) in. (mm)	Minimum Passing(2) (% by weight)
12 (305)	100
6 (150)	50

Notes:
(1) Indicates square mesh sieve
(2) As measured without protruding metal wires
(3) No "U-shaped" pieces allowed

Tire shreds to be mixed with soil, prior to use as ADC material, shall also conform to the above requirements. However, it may be desirable to use smaller size shreds with soil.

Prior to shredding, the volume of tire shreds required for a daily use as ADC should be estimated to ensure that sufficient shredded material is available. To estimate the amount of tire shreds necessary, it can be assumed that 1 yd^3 (0.77 m^3) of shreds is produced from approximately 50 whole tires. This value can vary given the size of the whole tires and the size of the shreds produced. Though there is no regulatory limitation to the maximum thickness of the ADC, it is recommended that a minimum 12-in. (305-mm) thick layer of tire shreds as ADC be placed over the working face. Therefore, for volume calculations, as a minimum the 12-in. (305-mm) thick layer should be assumed.

Tire size limitations will vary by shredder. Some shredders require that truck and heavy equipment tires be cut into quarters prior to shredding. Material specifications (Table 1) require that 100% of the shreds are smaller than 12-in. (305 mm), no "U-shaped" pieces are allowed, and at least 50% (by weight) of the shreds are smaller than 6 in. (150 mm) in size. Generally, rough shreds (approximately 6 to 12 in. (150 to 305 mm)) can not be produced by a single pass through a shredder. Therefore, to produce tire shreds with a maximum dimension of 12 in. (305 mm) and to prevent “U-shaped” pieces, it is necessary to screen the shreds and recycle the oversize pieces back through the shredder. Tire shreds retained on the screen can be cycled back through the shredder for smaller, more workable shreds (approximately 2 to 6 in. (50 to 150 mm) in size). The knives on the shredder cutter should be maintained to keep a sharp edge. This will result in fewer exposed metal wires. Excess loose steel may be removed from the tire shreds after the shredding process by an in-line magnet.

5.8 Mixture of Tire Shreds and Soil

Tire shreds can be mixed with soil and the mixture used as ADC material in order to apply tire shreds during wet weather or to reduce a potential for fire hazard at a landfill. Generally, the larger percentage of soil in the admixture, the better performance that can be expected of the ADC material with respect to these two criteria. The performance of a mixture of shreds and soil, with 30% to 50% soil by weight, approaches that of a soil itself.

The mixing of materials can be performed using a dozer or equivalent equipment. It is recommended that mixing, if performed on the working face of the landfill, be performed by spreading a layer of shreds approximately 6 in. (150 mm) thick followed by 6 in. (150 mm) layer of soil. The two materials then should be mixed by a scarifier mounted on a bulldozer or similar equipment. If the mixing is performed in a stockpile, it is best performed by a front-end loader or by placing alternating layers of shreds and soil followed by mixing with a scarifier. Mixtures of shreds and soil tend to segregate during handling and placement.

Since the tire shreds tend to clump together due to the presence of the metal wires protrusions, the consistent placement of tire shreds in lifts less than 9 to 12 in. (230 to 305 mm) is rather difficult.

5.9 Placement of Tire Shreds

After the whole tires have been shredded they may be transported to the working face of the landfill. Despite the possibility of metal wire protrusions causing flat tires in rubber-tired landfill equipment, rubber tired-loaders and rubber-tired trucks have been routinely used to transport tire shreds to the working face. A possible alternative to conventional rubber-tired equipment is the use of solid rubber-tires on loaders. A track-mounted loader, which would not be affected by metal wires, could transport only a few cubic yards of tire shreds at a time, thus rendering this equipment is generally less practical for this application.

The actual placement and spreading of tire shreds are similar to that of aggregate material. To spread tire shreds over refuse within the MSW landfill working face, a track-mounted dozer, track-mounted loader, or steel-wheeled compactor with a blade should be used. Experience has indicated that 3-in. (75-mm) shreds are spread most easily on slopes 3H:1V or flatter using small equipment rather than large.

As stated in the regulations, the minimum thickness of ADC must be demonstrated by the operator to be sufficient to control disease vectors, fires, odors, blowing litter, and scavenging. The required thickness for earthern material as ADC is 6 in. (150 mm). The recommended thickness for tire shreds as ADC is 12-in. (305 mm). To achieve this thickness, tire shreds are usually placed in a single lift. It is recommended that the ADC tire shreds be compacted by 2 to 6 passes of a landfill compactor or similar equipment. The purpose of compaction is to rearrange and densify the shreds thereby eliminating large voids that could allow rodents and insects to access the waste. The actual number of passes should be sufficient to produce an ADC layer in which the shreds are well packed together with no large voids between the shreds.

To reduce fire hazard within the landfill, it is recommended that every seventh working day (i.e., approximately once a week), a compacted soil cover, a minimum 6-in.

(150-mm) thick, be placed instead of tire shreds. Soil should be placed and compacted on the working face in accordance with existing landfill operating procedures.

In lieu of using tire shreds as ADC, a mixture of tire shreds and soil may be used. The mixture should be prepared prior to transporting and placement, and should be placed following the same procedure as described herein. If mixture with more than 50% soil is consistently used at a landfill, recommendations regarding the placement of a soil cover on the seventh day or prior to rain are not applicable. Using a mixture of fine-grained soil and tire shreds will reduce infiltration of rain water into the landfill and reduce fire hazard as compared with ADC consisting solely of tire shreds. Adding soil to the ADC will also affect the engineering properties of the material.

5.10 Restriction in Use of Tire Shreds as ADC Material

In order to meet performance criteria of an ADC material, the use of tire shreds (without admixed soil) must be restricted to the following conditions.

- Tire shreds shall not be applied during rain or when there is a local forecast of greater than 40% chance of precipitation within 8 hours of application time in the vicinity of the landfill.

- If rain is predicted within 8 hours, soil or other appropriate ADC shall be used for daily cover and all exposed ADC tire shreds, previously placed as ADC, shall be covered with soil or other approved ADC material.

- Compacted earthen material shall be placed over the working face at least once a week and at the end of any operating day preceding closed days.

- Soil shall be stockpiled in the vicinity of the landfill working face, which has been covered with tire shreds, to cover all shreds exposed to atmosphere in case of fire.

Additional restrictions may be imposed by local regulatory agencies and should be identified on a site by site basis prior to use of shredded tires as ADC.

5.11 Monitoring Program

5.11.1 General

A monitoring program, to monitor the compatibility of this application with environmental conditions and landfill operations, should be implemented to assure that tire shreds, used at a MSW landfill as ADC material, meet the performance standards for landfill daily cover. This recommended program requires the participation of both the EA and the landfill owner/operator [CIWMB, 1990]. The program and related performance standards are described in Section 20685 of Title 27 of the CCR.

5.11.2 Monitoring by Owner/Operator

Landfill owner/operator participation in this program includes regular (i.e., at least once a week) visual observations of the cover performance including:

- disease vectors in and around the working face;
- odors emitted from the working face;
- waste material being carried away by wind;
- evidence of fires within the landfill;
- slope movement;
- other conditions, which may affect the environment, landfill stability, operations, or personal safety.

A logbook should be maintained to record observations. If any of the above situations is observed, the landfill owner/operator is responsible for notifying the EA and, if applicable, other appropriate agencies, and to initiate the requirements of Section 20685 of Title 27 of the CCR (e.g., fly grill survey, ambient air sample collection and testing). The logbook shall be available to the EA, if required.

5.11.3 Monitoring by Enforcement Agency

Regular (at least monthly) site visits should be conducted by the EA to assess the performance of the tire shreds as daily cover material. As a minimum, the EA should review the logbook (see Section 5.11.2), review the landfill personnel involved in the tire shred ADC program, and inspect the site during the placement of the tire shred ADC material. The results of the inspection should be communicated to the landfill owner/operator at the earliest possible date.

5.12 Documentation

It is recommended that, if tire shreds are utilized as ADC material at a MSW landfill, the receipts for weight or volume of material used (i.e., trip tickets) be retained in landfill files. The project files, including the logbook, shall be made available to the regulatory personnel upon their request.

5.13 Health and Safety

As discussed (Section 4.3.8), uncontaminated whole scrap tires or tire shreds are considered non-hazardous inert materials. Thus, the material should have no health effects or impacts on humans. Employees, who have prolonged contact with whole scrap tires or tire shreds, however, should practice good personal hygiene by frequent washing of hands and arms with soap and water.

"*Standard Practice for Use of Scrap Tires in Civil Engineerng Applications*", being developed by the ASTM [1997c], includes a material safety data sheet for whole scrap tires. A summary of this material data sheet is provided herein. (For detailed information, one shall referred to the cited source.)

- No known health effects occur due to accute (short term) exposure).

- The material contains untreated naphthenic or aromatic extender oil. This oil could be released from the surface through skin contact. Prolonged contact with these oils has been shown to cause skin cancer in laboratory studies with animals. Untreated naphthenic or aromatic oils are classified as carcinogenic by International Agency for Research on Cancer. Prolonged or repeated contact may cause skin irritation or sensitization (allergic skin reaction).

- Employees, who have prolonged contact with whole tires or tire shreds, should practice good personal hygiene by frequent washing of hands and arms with soap and water. Contaminated clothing should be remove and laundered before reuse. A shower should be taken at the end of each day. Hands should be washed before eating, smoking, or using the restroom.

- Use of suitable personal protective equipment (PPE) including eye protection and protective gloves and shoes is recommended.

- Rubber tires contain potentially carcinogenic materials (including nitrosamines), carbon monoxide and dioxide, acrid fumes, and flammable hydrocarbons may be liberated as a result of thermal decomposition or combustion. The smoke and fumes, that result from thermal decomposition or combustion, should be avoided.

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7. LIMITATIONS

This report was prepared in general accordance with the accepted standard of practice which existed in Northern California at the time the project was performed. It should be recognized that definition and evaluation of environmental conditions is a difficult and inexact art. Judgments leading to conclusions and recommendations are generally made with an incomplete knowledge of the conditions present. No other representations, expressed or implied, and no warranty or guarantee is included or intended.

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