RINGS OF FIRE
Revisited

Tire Fire Prevention and Suppression

Office of the State Fire Marshal

State of California

RINGS OF FIRE: Revisited

Fire Prevention and Suppression of Outdoor Tire Storage

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Produced by: IMC Productions, California State University, Chico

Executive Summary

Tire fires are hot, long and frustrating to emergency responders who define success as being able to mitigate every emergency situation quickly. Tire fires can last months and in some cases years polluting the air, soil, and water. There are several issues that make outdoor storage of tires problematic. The first issue is the volume of tires that are generated every year— about 300 million nationally. California's commuter culture generates 33.3 million alone. With 280 million tires already stored in sites across America, outdoor storage of scrap tires appears to be a waste management issue that the fire service will be dealing with for a while.

The second issue that adds to the tire storage problem is the tire's geometry. Their hollow doughnut shape traps oxygen and shields the deep seated tire fire from extinguishing agents. The tires shape and the fact that they are water repellent means that most extinguishing agents like water and foam are relatively powerless against large tire fires.

The third issue is the tires impact on the environment. The by-products of combustion not only pollute the atmosphere but can also leave toxic residual in the soil and can seep into above and below ground water sources. Unregulated tire piles provide habitat for wild animals and disease carrying pests like mosquitoes. These are but a few of the problems and realities that this training program will help you come to terms with.

Program Goal

The expressed goal of this program is to provide fire professionals and enforcement officers, along with waste tire owners and operators, up-to-date information so that you can make informed decisions regarding the outdoor storage of tires.

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CHAPTER 1

History and Industry Background

Introduction

The origins of the tire storage problem began with the discovery of latex- a product harvested from rubber trees in South America and used by the indigenous South American people. But, it wasn't until a process was invented that stabilized this natural product that natural rubber could be used for industrial purposes. This Chapter presents a brief history of tires Along with background information about the waste tire industry and the impact industry practices have on emergency response.

Vulcanization

The vulcanization process, which transforms natural rubber into a substance with the stability and durability to be useful for tires, was first discovered in approximately 1839 by Charles Goodyear. Rubber tires were first invented in the late 1800s for bicycles, but competent air-filled rubber tires were not developed until the early 1900s.

Natural Rubber

Prior to the invention of vulcanized rubber by Charles Goodyear in 1839, natural rubber had few industrial uses. South American natives had been using natural rubber for centuries to make items such as water resistant shoes, baskets and boats. However, products made from natural or India rubber, as it was known, melted in hot weather, froze and cracked in cold, and adhered to everything they touched. Many inventors in the early 1800s experimented with ways to increase the stability and durability of rubber. In 1830, Charles Goodyear began experimenting with raw rubber to turn it into a useable product. Over the next nine years, Goodyear spent much of his time working with rubber. By 1839, he had a product the consistency of gum, which he had hardened by mixing the rubber with sulfur and treating it with an acid gas. When Goodyear's gummy substance accidentally landed on a hot stove, he discovered it had reached the consistency he had been trying to achieve, and the vulcanization process had been discovered.

Rubber was first used to make tires in Belfast, Ireland in 1888, by John Dunlop. Dunlop used a thin rubber sheet covered with fabric to make air-filled tires for his son's bicycle. In 1889, Dunlop's tire concept was sold to Harvey du Cross, Jr., the founder of the Dunlop Rubber Company. The first air-filled tires for cars were made by André Michelin in 1895, for a 350-mile auto race from Paris to Bordeaux. However, numerous flat tires during the race caused the air-filled tire to be thought of as a failure for automobiles.

In 1911, the Hardman Tire & Rubber Company became the first to produce a combination tire and tube. An air filled inner tube was surrounded by a hardened rubber tube that was reinforced with fabric, creating the first usable air-filled tire for automobiles. A patent for the first tubeless tire, which used a two-piece arrangement similar to the Hardman company design, was granted in 1903, but it wasn't until 1954 that the first automobile with tubeless tires was offered on the market.

In 1908, Frank Seiberling, founder of the Goodyear Tire and Rubber Company, built a machine that cut grooves in the hard tire surface for traction. In 1910, the B.F. Goodrich Company added carbon to the rubber to reduce wear. By 1920, the life expectancy of an automobile tire was 13,000 miles.

Synthetic Rubber

Contact was cut off with rubber producers in Asia and South America at the beginning of World War II. The lack of natural rubber forced tire companies to develop a petroleum-based synthetic rubber. The Goodyear Tire and Rubber Company began making synthetic tires in 1937 and patented a man-made substance called Chemigum. By 1950, man-made rubber made up half of all tires produced.

Today, over 60 percent of a tire is synthetic. Synthetic rubber is made from derivatives of petroleum, coal, oil, natural gas, and acetylene. Synthetic rubber is comprised of copolymers, which can be altered to achieve specific properties that make the product better suited for different uses. The synthetic rubber generally used for tires is called styrenebutadiene rubber (SBR), which is one of the earliest synthetic rubbers and whose properties are close to those of natural rubber. Synthetic rubber ages and weathers better than natural rubber, is more resistant to chemicals such as oil, solvents, oxygen, and ozone, and remains resilient over a wider temperature range than natural rubber. However, synthetic rubber tends to allow greater heat buildup from flexing and is less resistant to tearing when heated.

Bias Ply Versus Steel Belt

The single change in the tire manufacturing industry that has had the greatest impact on the current waste tire pile issue was the transition from bias ply to steel belted tires. Commercial tires were originally constructed in a bias ply configuration. In a bias ply tire, the cords in a single ply run across the tire in a crisscross pattern to provide strength. Modern tires, however, are constructed with a steel belt (radial-ply belted) or a rigid belt of synthetic fabric (bias-ply belted) to provide strength.

Belted tires provide longer wear than bias ply tires. The significance of this change to the waste tire industry is that steel belted tires are generally not retreaded but discarded after use instead of recycled. Additionally, the steel in discarded tires is a source of heavy metals that are released during a tire pile fire.

Chemical Compounds of Tires

Vulcanizing natural rubber resulted in rubber that was harder and more stable in the earliest tires. The vulcanization process basically consisted of adding sulfur to natural rubber, treating it with acid, and heating the product. Natural rubber essentially consists of a hydrocarbon compound called isoprene. This natural rubber was often mixed with fillers, pigments, antioxidants, vulcanizing agents, etc. Rubber was reinforced with fabric beginning in the late 1800s.

Modern tires consist of four major components: the body, tread, beads and sidewalls. The body is comprised of multiple layers of rubberized fabric, which is generally made of rayon, nylon, or polyester. Chemically treated rubber comprises the sidewalls and tread. The beads are two steel hoops that hold the tire to the wheel rim.

Today, a tire's chemical composition typically includes: natural and synthetic rubber polymers, oil fillers, sulfur and sulfur compounds, phenolic resin, clay, aromatic, naphthenic, and paraniffic oil, fabric, petroleum waxes, pigments such as zinc oxide and

Table 1: Tire Chemistry

titanium dioxide, carbon black, fatty acids, inert materials and fiber made from steel, nylon, polyester or rayon. These compounds are listed in the table to the right.

Waste Tire Markets and Uses

Many options and markets have been developed for reusing waste tires, in industries ranging from agriculture to civil engineering to sports. When old tires are reused for other purposes they are diverted away from the waste stream. Currently the California Integrated Waste Management Board (CIWMB) calculates that 74% of the scrap tires generated in California are being diverted to other uses. The CIWMB and other agencies across the nation are continually encouraging the development of new markets. One area of diversion for California is to export a significant number of waste tires to foreign countries. In 1999, an estimated 1.5 million tires were exported for recyclable uses.

Retreading

Perhaps the most direct reuse of waste tires is retreading, in which the old tread is peeled from the casing, the casing is buffed, and a new tread is applied to the old casing. The old tread can then be reused in another application, and the retreaded tire put back into active service. According to the CIWMB, retreading applies mostly to heavy truck tires, since steel-belted passenger car tires are generally not retreaded. However, the United States Fire Administration and the Federal Emergency Management Agency report that as of December 1998, approximately 38 million passenger car tires and truck tires were retreaded.

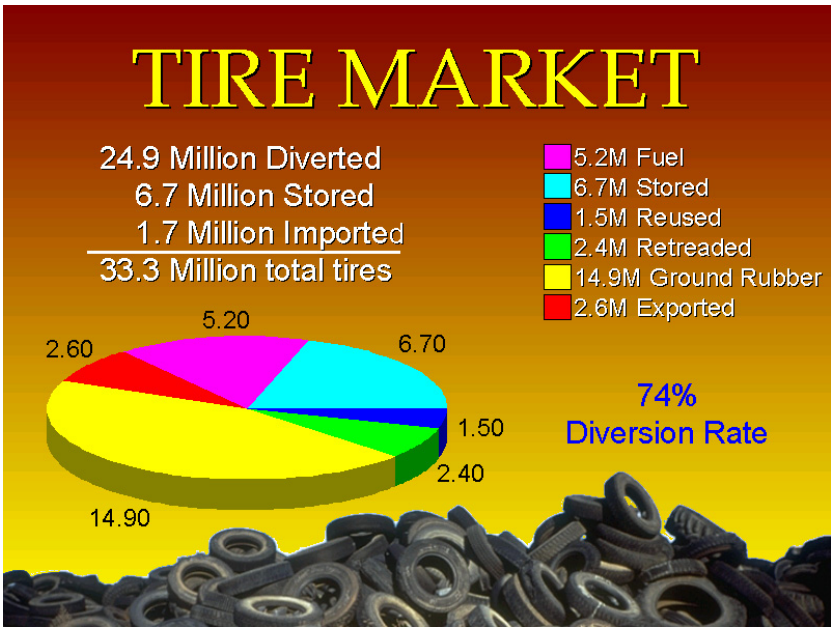

Table 2: Tire Market

Ground Rubber

Numerous value-added rubber products are made from "ground" or "crumb" rubber (made by finely shredding rubber after removing the steel cords) or rubber in other forms from waste tires. Some examples are listed in the Table 3 below.

Athletic mats	Running tracks	Playground chips	Carpet padding
Toys airplane	Shock absorbers	Stock Feeders	Fences
Dock bumpers	Boots	Door mats	Gloves
Hockey pucks	Soles for sandals	Mud flaps	Speed bumps
Roofing materials	Soaker hoses		

Table 3: Examples of reused products

Another use of ground or crumb rubber is its application to roadway paving. Crumb rubber is mixed with standard road paving materials to create Rubberized Asphalt Concrete (RAC) or Rubber Modified Asphalt (RMA). Crumb rubber from as many as 800 to 1,200 waste tires is used per mile of a two-lane, 3-inch lift roadway.

In many of the products listed above the waste tire must be reduced to "ground" or "crumb" rubber which is then formed into specific products. Tire reduction processes require a feedstock of waste tires stored on site. The tires are usually not on site very long as they are constantly being processed into shreds, ground or crumb rubber. Nevertheless, the storage of whole and/or altered tire material pose a fire risk to the surrounding exposures and properties.

Civil Engineering Applications

Several significant applications have been identified and developed in the civil engineering field. These applications include artificial reefs, breakwaters, retaining walls, and crash barriers, to name a few. Some of the more notable markets are listed below:

- Alternative Daily Cover (ADC) – The CIWMB has approved the use of shredded tires as an ADC at municipal solid waste landfill sites in the State of California. California law (27 CCR Section 20614) requires that daily cover be used to cover "the active face at least at the end of each operating day in order to control vectors, fire, odor, blowing litter, and scavenging." Currently only two municipal landfills in California use ADC, but the use of ADCs represents a potentially significant market for waste tires (CIWMB, 2002b).
- Loose Fill – Using shredded tires as fill for low-lying areas or trenches provides good drainage. The shredded tires are generally covered with a thin soil layer.
- Slope Stabilization – Use of shredded tires on inclines can reduce the risk of mud and landslides.
- Levee Slurry Walls – Still in the experimental stages, chipped (1-2 inch pieces) tires can be added to a slurry mixture to form a levee wall.
- Landfill Leachate Collection Systems – Shredded tires can be used as filter material in landfill leachate collection systems, allowing leachate to drain to a sump for transfer to a treatment system.

Energy Options

The largest market for reuse of waste tires both in the nation and in California is the use of tires as a fuel supplement in pulp and paper mills, cement kilns, and coal co-generation facilities. According to the CIWMB, nearly 39 percent of all waste tires generated in California in 1999 were used as fuel. Tire Derived Fuel, or Tire Diverted Fuel (TDF), is a high quality fuel that can produce up to 15,000 British Thermal Units (BTU) per pound of tire material. Additionally, tires generally create less ash and sulfur than some types of coal, and when mixed with coal, burn completely minimizing chemical emissions to the atmosphere.

btu/pound	kilojoules/kilogram	fuel type
18,000	41,940	Fuel Oil
15,000	34,950	Scrape Tire
13,500	31,455	Petroleum Coke
12,000	27,960	Bituminous Coal
7,800	18,174	Sawdust
7,400	17,242	Newspaper
3,500	8,100	Solid Municipal Waste

Table 4: Heat Release

Three cement kilns in California used 4.1 million tires as supplemental fuel. Tires were used because they have higher heat energy by weight and they reduce emissions of certain regulated pollutants. Additionally, the steel belts in many tires produce minor amounts of iron ore, which is used in the cement making process. Coal co-generation plants can burn shredded tires with the coal to produce energy. The CIWMB funded emissions tests at two coal co-generation plants in northern California. The results of these emissions tests revealed that these two coal co-generation plants could use 1-2 million tires per year.

Combustion By-products Barriers to Reuse/Recycling

The CIWMB and other agencies across the nation are continually encouraging the development of new markets. This includes not only identifying new applications for recycled rubber, but also identifying and attempting to eliminate barriers to recycling.

One such barrier is the by-products of burning tires. Markets, however, have been identified for many of the combustion products. Table 5 below shows some of the uses for the major combustion by-products. For example, calcium from the quick lime used as a filter in the stack scrubbers at the Modesto Energy Plant in Modesto, California, absorbs sulfur from flue gases, forming calcium sulfate, or gypsum.

Tire Disposal & Storage Options

Effective disposal options are continually being sought for the hundreds of millions of tires that are discarded each year. Currently there are no federal laws or regulations specifically governing waste tires. At the State level, 48 states currently have some law or regulation regarding disposal and management

Calcium sulfate (gypsum) - Agricultural additive for clay soils
Zinc oxide (from fly ash) - Smelting, fertilizer and cattle feed companies
Iron oxide (from furnace) - Cement production

Table 5: Byproducts of Stationary Combustion

of waste tires. While each state has its own program, some common features include licensing or registration requirements for waste tire haulers, processors and some end users; manifests for waste tire shipments; limitations on who may handle waste tires; financial assurance requirements for waste tire handlers; and market development activities.

Although responsible means for disposal, such as recycling, reuse and energy-recovery have become more common, the tire dumps of the last forty years continue to present environmental and safety hazards that will continue into the foreseeable future. Waste tires are not desirable in standard landfills because, when buried, the tires tend to trap air and “float”, which interferes with future landfill reclamation operations. As permitted landfill space diminishes, it is necessary to limit the types of accepted material to those better suited to future reclamation. However, this creates additional need for suitable waste tire storage and disposal facilities.

Aside from recycling or reuse options, tire disposal options involve alternative methods of storing waste tires at waste tire facilities. Several of these storage options are described below.

Barrel Stacks– Whole tires stacked on top of one another. Typically this is used for used tires that have been graded as reusable tires. These graded tires may be resold, retreaded, or exported to foreign dealers. A fire in barrel stacked tires generates flames in a whirlpool effect straight up into the air. Lateral extension of the fire is possible, but does not extend as fast as randomly stacked tires.

Laced Stacks– Whole tires stacked in an overlapping or herring bone pattern. This "laced" stacking takes advantage of space, exposes less surface area of the tires to a fire, and may be used as a retaining wall for randomly stacked tires. The biggest problem or danger with a fire in a laced stacked is that the tires are more difficult to pull apart without bringing a whole section of tires down.

Random Stacks– This is the most common storage method where tires are simply tossed into piles. This method requires little effort or handling by a site operator but also requires the most storage space. Randomly stacked tires are a greater fire risk because they expose more tire surface area and create greater volumes of air between tires than other stacking methods.

Bundling/Bailing– There are several baling techniques. In one method, up to 18 whole tires, approximately 11 feet, can be compressed into 30-inch bundles. This process clearly reduces the space required to store tires and reduces interior spaces decreasing potential wildlife and insect habitats. However, studies have shown that even after 6-months of compression, when the bundled tires are released the tires spring back to their original shape. In a fire, the steel wires holding the tire bundle together are broken by high temperatures and pressure from the bundled tires. As the tires quickly return to their original size and shape, oxygen and fire are drawn into the interior space of the tires fueling the fire like a bellows.

Another baling method involves bailing approximately 100 tires into a large square bale. The bale measures about 6' by 6' by 3'. These bales weigh a ton and can be used for engineering applications such as on the banks of waterways or arroyo's and then covered with

cement to hold the banks in place.

Shredding– In this process tires are ripped and shredded into smaller pieces by a shredding machine. One pass through a shredding machine yields 'single pass' or 'chunk' tire material. If this material is run through the shredding machine several times, 2" Tire Derived Fuel (TDF) is produced. This 2" TDF is used in cement kilns and paper factories. Shredding reduces tire volume- eliminating interior air space, and prevents water collection and breeding of mosquitoes and other wildlife. Shredded and 'chunk' tire pile fires tend to be less intense and create less smoke than whole tire pile fires. The flame height is no more than 1 to 3 feet and can be extinguished with a fog pattern hose stream.

Summary

This chapter provides the emergency responder with an overall history and background of the waste tire business. The information will be useful as you enforce site specific fire prevention measures or should you become involved with managing an outdoor tire pile fire.

CHAPTER 2

Fire Prevention

Introduction

Prevention of tire fires is paramount because of the potential size, environmental impact, duration, and cost of a major fire. A successful fire prevention program begins with the development of a rapport between the fire prevention officer and the waste tire owners or operators. Additionally developing a working relationship with other agencies including the local County Health Departments and local planning commission for Air and Water Quality Control Boards are all key to a successful fire prevention program.

Ignition Sources

Any discussion of fire prevention for waste tire piles should be prefaced within the historical context of tire fires around North America. Arson is the leading cause of tire fires. When enforcement of state and local laws gets the attention of waste tire pile owners- the piles suddenly catch on fire. Tire piles are also an attractive target for juvenile arsonists. Other sources of ignition include lightning strikes, grass and brush fires, and ignition sources such as welding or smoking in and around the tire pile. The table below shows some of the historic fires, the number of tires in the pile and the suspected source of ignition.

TIRE FIRE HISTORY

Year	Amount	Event
1999	7 M	Westley, California
1998	8 M	Tracy, California
1997	3 M	Gila River, Arizona
1996	2 M	Fresno, California
1993	3 M	Inwood, West Virginia
1990	12 M	Hagersville, Ontario
1990	3 M	Saint Amable, Quebec
1989	3 M	Danville, New Hampshire
1989	2 M	Catskill, New York
1988	5 M	Cocranville, Pennsylvania
1987	3 M	Hudson, Colorado
1986	9 M	Somerset, Wisconsin
1984	4 M	Everett, Washington
1983	9 M	Winchester, Virginia

Table 5: Tire Fire History

Six Signs That a Tire Company is in Trouble

Experience has shown that there are a number of indicators or a combination of indicators of an impending tire fire. There are historic cases of government crackdowns on outdoor tire storage facilities where the aggrieved owners have opted to burn their piles instead of addressing the notice of correction. You can anticipate a potential tire fire catastrophe by closely monitoring the waste tire owners and operators. Six signs that a waste tire company is in trouble include:

1. Increasing Piles in height, width, and volume.
2. Permit/code violations—cited by inspection/enforcement authority.
3. Change in ownership—a shell game for owner liability.
4. Company files for bankruptcy—can they afford to clean-up the pile?
5. High personnel turnover—inexperienced new employees.
6. Loss of permit—due to code violations.

Unified Enforcement

The single best deterrent for waste tire pile fires is an active enforcement program. Often times no single agency has all the information regarding the owner/operator, the facility, or the ability to monitor increases in tire pile size. For this reason, a unified enforcement program should be initiated. Unified enforcement can be accomplished through an environmental crimes task force or can be an association of local agencies all trying to ward off potential problems. The agencies involved in a unified enforcement program can vary but can include, hazardous materials investigators, building officials, fire officials, law enforcement, Integrated Waste Management Board, Department of Health, District Attorneys office, and elected officials. Primary code enforcement falls to the CIWMB, local fire service and local health departments.

The CIWMB is charged with developing and enforcing regulations and codes associated with waste tire piles. The authority and framework for enforcement is set forth in the California Public Resources Code. The CIWMB regulations require the local fire department to approve fire safety plans for all waste tire storage facilities and local health departments to implement vector controls.

Local fire departments have the ability to adopt, through local ordinance, the fire safety provisions detailed in the CIWMB Title 14 California Code of Regulations.
Or, the local fire department may access national standards through Title 19 for the prevention and enforcement of waste tire piles. Currently, the California State Fire Marshal is working with CIWMB to transfer the fire safety regulations in Title 14 to Title 19 so that the regulations will be enforceable by all fire departments statewide. Until then, local fire departments should adopt a local ordinance or reference national standards for local enforcement.

Local health departments are primarily involved in approving vector control treatments. State regulations contain provisions for local enforcement agencies to require site specific measures that differ from those specified in the regulations, as long as they fulfill the spirit of the laws in terms of protection of life and property and are approved by the CIWMB.

Enforcement Mechanisms

The primary enforcement mechanisms available to the CIWMB are the permitting system and the system of monetary fines of the California Public Resources Code (PRC). Permits are required to store waste tires at a facility. Violations of state regulations, or provisions of the major or minor waste tire facility permits, result in civil actions such as suspension/revocation of a permit, a monetary fine, and/or imprisonment. According to the PRC, a negligent violation of state laws can result in a fine of between $500 and $5,000 for each occurrence or for each day of a continuing violation. An intentional violation can result in a fine of up to $10,000 per occurrence or per day of a continuing violation, imprisonment in the County jail for up to one year, or both fine and imprisonment.

Unpermitted vs Permitted Waste Tire Pile Sites

Sites are best characterized as "permitted" or "unpermitted." Unpermitted sites are tire piles that have been dumped on a property with or without the knowledge of the property owner. The sites are generally hidden and unknown to enforcing agencies. Tire piles can often be hidden as brush and shrubs grow up around and through the tires thus adding an additional fuel source to this potentially dangerous condition. There is no control of indigenous wildlife in the vicinity of the tire piles adding to the threat of disease. Further, access to these sites is often very limited, thus enhancing fire-fighting challenges. The most critical issue associated with unpermitted sites is the absence of knowledge that these sites exist and where they are located. At a minimum, knowledge of these sites is critical for the management of the fire and for the safety of the fire fighters.

Permitted sites on the other hand, have a known location and operation. In many cases the owner operator has applied for a business license locally along with a permit from the CIWMB. The fire department becomes involved when asked to sign-off on a fire protection plan required by CIWMB before a site permit can be issued. This requirement will allow for notification of a tire facility being allowed in your jurisdiction. The following sections identify the minimum fire safety requirements for a waste tire storage facility.

Tire Pile Regulations

There are no Federal regulations pertaining to storage and disposal of waste tires. The legislative responsibility lies with each individual state. The Environmental Protection Agency (EPA) does, however, have a number of programs and initiatives to help reduce the millions of waste tires across the nation. The National Fire Protection Association (NFPA) publishes standards and codes pertaining to the outdoor storage of tires. The Western Fire Chiefs Association also publishes a model code with specific information regarding waste tire storage in the Uniform Fire Code.

In California, Title 14 of the California Code of Regulations (CCR) contains the most comprehensive regulations associated with waste tire storage and disposal. The CCR's apply to any solid waste facility storing 500 or more waste tires, any major (5,000 or more) or minor (5,000 or less) waste tire facility storing tires indoors or outdoors. Tire piles of less than 500 are not regulated and any fire in them is easily mitigated by the local fire department.

To build a comprehensive regulation CIWMB combined the more restrictive storage requirements in the Uniform Fire Code and the NFPA Standard. For example, the Uniform Fire Code restricts the size of a single tire pile to no more than 5,000 square feet of continuous surface area and not to exceed a total

volume of 50,000 cubic feet or exceed a height of 10 feet above grade. Conversely, NFPA restricts the storage of waste tires to no more than 250 feet in length and 50 feet in width and no more than 20 feet in height. The NFPA requirement would allow for 1,250,000 cubic feet of storage. In this example, tire pile size in the Uniform Fire Code is much more restrictive than the NFPA requirements. It was the more restrictive requirement that was incorporated into the California Code of Regulations. The specific regulations and code requirements are detailed here:

Emergency Response Plan

The operator of the waste tire facility shall maintain a copy of the "Emergency Response Plan" at the facility. At the time of permit issuance the approved Emergency Response Plan shall be forwarded to the local fire authority by the permittee. The plan shall be revised as necessary to reflect changes in operations of the waste tire facility or with additional requirements of the local fire authority. The local fire authority and the CIWMB shall be notified in any changes to the Emergency Response Plan within 30 days of the revision.

Fire Control Measures

This section mandates that certain measures are taken at each qualifying facility to minimize the risk of fire.

The four measures include:

1. Communication equipment shall be maintained at all facilities, if they are staffed by an attendant, to ensure that the site operator can contact local fire protection authorities in the event of a fire.
2. Adequate equipment to aid in the control of fires must be provided and maintained at the facility at all times. At a minimum the following items shall be maintained on site and in working order: one dry chemical fire extinguisher, one 2.5-gallon water extinguisher, one 10-foot long pike pole, one round point shovel, and one square point shovel. One dry chemical fire extinguisher with a minimum rating of 4A:40BC shall be carried on each piece of fuel-powered equipment used to handle waste tires. This equipment is to be used by on-site personnel. On-site personnel have the best opportunity to keep a small fire from becoming a catastrophe.
3. An adequate water supply shall be available for use by the local fire authority. The water supply shall be capable of delivering at least 1,000 gallons per minute (gpm) for three hours in facilities with fewer than 10,000 waste tires, or 2,000 gpm for three hours if the sum of altered or whole tires exceeds 10,000 waste tires.
4. The fire authority has the option to require additional tools and equipment for fire control and the protection of life and property. This may include the availability of earth moving equipment or other approved means of controlling a fire.

Facility Access and Security

This section mandates that certain measures be implemented at each qualifying facility to provide access to emergency vehicles, maintain security from unauthorized persons, and provide signage with a minimum amount of information. The measures identified in the regulation include:

1. Signs - at the facility entrance that gives the name of the operator, the operating hours, and site rules.
2. Attendant – an attendant shall be present when the facility is open for business if the facility receives tires from a source other than the site operator.
3. Access - An access road to the facility must be maintained passable for emergency equipment and vector control vehicles at all times. Unauthorized access must be strictly controlled.

Storage of Waste Tires

Waste tires shall be restricted to individual piles, which include stacks and racks of tires that do not:

1. Exceed 5,000 square feet.
2. Exceed a volume of 50,000 square feet.
3. Exceed a height of 10 feet.
4. Exceed a height of 6 feet when a tire storage unit is located within 20 feet of the property boundary.
5. Waste tires shall not be located within 10 feet of any property line or perimeter fencing.
6. The minimum distance between waste tire piles and between waste tire piles and structures that are located either on-site or off-site shall be as specified in the Separation Table.
7. Waste tires shall be separated from vegetation or other potentially flammable materials by no less than 40 feet.

TIRE PILE SEPARATION DISTANCES	**Tire Storage Pile Height (Ft.)**		
Length of Exposed Face (Ft.)	6	8	10
25	50	56	62
100	84	100	116
150	99	117	135
200	111	130	149
250	118	140	162

Table 7: Tire pile separation distances

8. Accessible fire lanes with a minimum width as specified in the Separation Table shall be provided between tire storage units.

9. Fire lanes shall be kept free of flammable or combustible material and vegetation.

10. Access to fire lanes for emergency vehicles must be unobstructed at all times.

11. Open flames, blow torches, or highly flammable materials, including but not limited to tire inner tubes, are prohibited within 40 feet of a waste tire pile.

12. Surface water drainage shall be directed around and away from the waste tire storage facility.

13. Waste tires at existing waste tire facilities shall not be stored on surfaces with grades that will interfere with firefighting equipment or personnel unless mitigation measures have been approved in writing by the fire authority or a fire safety engineer registered by the State of California.

14. Measures established by a fire safety engineer shall be subject to approval by the local fire authority.

New Waste Tire Facilities

1. Shall not be sited in any area where they may be subject to immersion in water during a 100 year storm unless the operator demonstrates to the board that the facility will be designed and operated so as to prevent waste tires from migrating off-site.

2. Shall not be located on sites with grades or other physical features that will interfere with firefighting equipment or personnel.

3. Tires must be removed from rims immediately upon arrival at the facility.

4. The site shall be designed and constructed to provide protection to bodies of water from run-off of pyrolytic oil resulting from a potential tire fire.

Indoor Storage

Though not in the scope of this program, it is important to note that some waste tire dealers have attempted to avoid out door storage regulations by filling warehouses with waste tires. Waste tires stored indoors should meet conditions set forth in "The Standard for Storage of Rubber Tires," National Fire Protection Association, NFPA 231D-1989 edition, unless the local fire authority determines that different requirements are necessary to meet the intent of the above referenced fire control standard.

Prevention for Tire Processing

Tire processing operations like chipping, or grounding, require piles of waste tires as a feedstock. The operation reduces waste tires to shreds or crumb rubber. There are no specific regulations for this type of operation but there are industry recognized recommendations for the prevention of fires in tire processing operations including:

1. Ten foot fence around the material storage area.

2. Rubber piles 30 to 60 feet from the perimeter fencing.

3. No ignition sources such as welding, smoking etc. near the rubber pile.

4. Rubber pile should be frequently rotated off-site.
5. Material should be kept sheltered from precipitation.
6. In the processing line clean out rotor assembly.
7. Install dust collection system.
8. Keep processing area clean and clear of combustible materials.
9. Install fire suppression system.
10. Provide access doors or ports to duct system every 10 feet.
11. The American Conference of Governmental Industrial Hygentist recommends a duct velocity of 2,500 to 3,500 feet/minute to prevent fine rubber particles from settling and plugging system. Experience suggests 5,000 to 5,500 feet per minute is needed to keep ductwork clean.
12. Air flow sensors should be installed in ductwork to monitor velocity.
13. Automatic shutdown of fans and manual shut-off switches near equipment operator should be installed to keep from feeding air to a duct fire.
14. Fire suppression systems need to have the ability to flood the ductwork with water or steam to displace oxygen and cool hot pieces of rubber.
15. Bag house dust collection systems require cloth bags that are pretreated by the manufacturer to remove small fibers from the woven cloth.
16. Nomex bags are recommended.

Alternative Means of Protection

While these regulations and recommendations specify the minimum fire safety requirements of a waste tire facility and waste tire processing operation, the CCR allows the local fire authority having jurisdiction to evaluate alternative means of protection. Local conditions and new technology may allow for other ways to protect tire piles and operations from a fire.

Summary

Understanding how tire fires have been traditionally started and by using aggressive and consistent code enforcement will help your department avoid the future tire fires. But with your understanding of industry storage and processing practices along with code specific information will also help you work out a site specific pre-plan. But if all of your efforts fail, you need to also understand the current trend in fighting waste tire pile fires is included in the next section.

CHAPTER 3

Pre-Fire Planning

Preplanning is essential in effective tire fire management. At a minimum, all local fire-fighting authorities should develop pre-incident plans, site safety plans, identify federal, state, and local Emergency Response Teams, and identify local and/or regional response contractors. Additional guidelines can be referenced using NFPA guidelines and codes, OSHA directives for hazardous waste and emergency response standards described in 29 CFR 1910.120 and 29 CFR 1926.65, paragraph (q): *emergency response to hazardous substance releases*, the United States Fire Administration Special Report on Scrap and Shredded Tire Fires (USFA, 1998), and the "Rings of Fire" text on fire prevention and fire suppression of scrap tire piles (COSFM, 2004).

Develop Pre-Incident Plan

Pre-incident plans are developed to identify the special considerations and hazards of a particular site or property so that responding units will know what to expect and how to proceed during initial operations. Pre-plans must accommodate the agency's standard guidelines and specify exactly how those guidelines are to be applied should a fire break out at a given location. All outdoor tire and rubber products storage facilities should be considered high-risk storage sites and pre-planned accordingly, regardless of the site location.

Included within the pre-incident plan is information and resource material useful to the incident commander. In the case of a tire fire, these resources would include maps of the area, information on the hydrographic conditions of the soil, water supply contingency plans, emergency contacts and a variety of other important considerations.

Also included in the pre-incident plan, should be anticipated assignments for mutual aid companies and organizational charts specifying the anticipated control sectors. The means of maintaining fire ground and incident management strategies (Incident Command System), should be anticipated and included in the pre-incident plans.

The following common elements of tire fires that need to be considered and included in the pre-incident plans includes:

- The anticipated establishment of a functional incident management system, to include command and control of all responders and workers.
- The early recognition of tire fires as potential hazardous materials (HAZMAT) incidents, with considerations given to treating them as such.
- Information regarding the site's location, layout, size and composition. Also information regarding access and egress routes, the physical infrastructure of the roads and other "access" considerations.
- Information management plans, to include resource request tracking forms, video recording of incident progression, and financial reimbursement requests.
- Access to local, state and federal agencies or organizations with environmental and/or emergency management responsibilities (Section 6.2.2).
- Access to local and regional contractors with specialized equipment (Section 6.2.3). Each of these elements of a pre-incident plan is further discussed in the following paragraphs.

Recognition of Hazmat Potential

The pre-incident plans should note that tire fires produce a variety of pollutants, and although not always toxic, should be regarded with a high index of suspicion. Since it is recommended that major tire fires be handled as hazardous materials incident, the preincident plans should call for first-responder HAZMAT precautions and subsequent activation of department HAZMAT personnel and resources.

Site Location, Layout, Size and Composition

The exact location and size of the tire storage yard or dump should be determined. This is often difficult and incompletely performed since many sites are located in remote areas or accumulate as the result of illegal dumping. Maps of the site should be updated and made available in the pre-incident plan. Ingress and egress plans for apparatus and personnel should be included. The development of additional access points should be planned with the means of maintaining or expanding accesses provided. The possible locations for a command post and any usable on-site buildings may also be identified.

Topographical, aerial and soil composition maps should be obtained and updated to show hydrants and water supply sources, accesses, interior lanes or passages, and fuel load configurations.

Schools, homes, and transportation routes near the site should be identified as "high risk" exposures and considered in pre-incident planning should evacuation or pollution control become necessary.

The location of any utilities on or near the site should be identified so responders can quickly shut off power to electrical or gas lines and prevent the run-off of contaminated water into storm drains or plumbing systems.

The condition of roads and access routes should be considered in the pre-incident plans in order to avoid a common problem of first-arriving units becoming stuck in mud or unable to exit a narrow access. The fire

department should identify how access can be made to remote sites. More information on access roads is contained in Section B – Fire

Tire Pile Composition

The composition of the tire pile should be considered since important differences exist in developing suppression strategies. Shredded or "chip" tire piles present different challenges than whole tires, as would the existence of plastics, metals, refuse or hazardous chemicals/waste. Additionally, the age of the pile and the local climate may affect the amount of rodent and insect infestation of the particular site.

Information Management and Resource Request Tracking

The amount of information, both written and oral, that is generated during a prolonged incident is overwhelming, and can cripple the command structure if it is not managed effectively. Therefore, an orderly system of information management should be designed as part of the pre-incident plans. A senior member of the command system should be designated as the Information and Resource Management (IRM) Officer.

All requests for major materials, supplies or resources should be coordinated by the incident IRM Officer. Similarly, all incoming resources and supplies should be reported to the IRM Officer. When another sector commander pulls a resource, notification should be immediately sent to the IRM Officer. In turn, the IRM Officer should make available a list of available supplies.

Video taping of the incident should also be included in the pre-incident plans. This will allow for post-incident analysis as well as documentation of fire department activity. Videotaping of requests and meetings with government officials and private parties can only assist in assuring that promised resources are delivered.

Identification of State and Local Emergency Response Teams

State and Local Emergency Response Teams should be a component to pre-planning. In the event of a tire fire, local fire fighting efforts for communities may not have sufficient resources to handle such an emergency.

Pre-incident plans should contain up-to-date emergency contacts for all local, state, and federal agencies or organizations with expertise or responsibility in management of environmental disasters. The lists should include phone numbers, facsimile numbers, addresses, and radio frequencies, if applicable.

Since emergency management structures differ across state and county lines, each fire department will have to research its own government structure and laws to determine the appropriate agencies to involve.

These agencies should participate in, or at least become familiar with, the pre-incident plans.
Examples of concerned agencies would be:

- State and local Police;
- Public Works agencies;
- State Department of Emergency Management;
- Regional offices of the Federal Emergency Management Agency (FEMA);
- Regional, State or Federal Environmental Protection Agency (EPA);

- State Division of Natural Resources or State Forestry Agency;
- State Fire Marshals office; and
- Finance, Purchasing and Budget agencies.

The pre-incident plans should assign the various government agencies to appropriate sections in the command system. This will allow for smoother transition in areas such as "environmental management" or "resource management" when those respective experts arrive on scene.

Identification of Local and or Regional Response Contractors

Identification of local and or regional response contractors is a necessary component of pre-planning for a tire fire response. A current list of contractors should be maintained at all times. Utilization of these contractors will enhance the response efforts in the event of a fire emergency. Having these contractors identified and coordinating their use in simulated drills with the local fire authority will provide the necessary training to manage the emergency and make informed decisions.

Contractors commonly utilized in a tire pile fire include:

- Providers of heavy equipment including but no limited to front-end loaders, track excavators or mid-size dozers;
- Construction and wood supply companies;
- Equipment repair and maintenance contractors;
- Fill dirt and gravel contractors;
- Canteen or food services providers;
- Sanitation or "Porta-John" companies;
- Public and private universities - departments of ecology, environmental engineering, etc.;
- Foam/chemical additives manufacturers;
- Oil reclamation and clean-up companies; and
- Aerial photography and Infrared reconnaissance sources (sometimes provided by State Police or a university).

Private contractors expected to participate in fire suppression activities, such as tractor operators, will need to be trained in the use of fire fighting personal protective clothing and gear, including self-contained breathing apparatus. Provisions should also be made for earth-moving equipment to accommodate SCBA cylinders or other such equipment in a way that will not restrict the operator.

The pre-incident plans should assign the various contractors to appropriate sectors in the command system. This will allow for more efficient operations in areas such as "maintenance" or "reconnaissance" when those respective contractors arrive on scene. The contractors identified in the pre-incident plans should participate in, or at least become familiar with, those plans.

Initial Tire Fire Response

Tire pile fires, like all fire incidents, should be managed under an incident command system (ICS), further it is recommended that these incidents be handled as hazardous materials (HAZMAT) incidents. In order to establish and maintain command and control of all response efforts associated with a tire pile

fire, a unified command (UC) should be established where all aspects of the incident can be calculated and communicated. Typically, tire fires involve active participation from multiple federal, state, and local agencies 24-hours a day for several months. Effective communication is imperative. Following an established site-specific safety and emergency response plan, or pre-incident plan, is the best approach to ensure timely and efficient containment of tire pile fires. Understanding the stages and characteristics of a tire fire will help the Incident Commanders in formulating an overall command strategy.

Tire Fire Dynamics (Stages of Combustion)

Basic concepts of combustion involve the transition of a material from a solid to a liquid to a vapor. This is true with tires as it is with almost any combustible material. One distinguishing difference between wood fires and tire fires is in a tire's ability to absorb radiant heat and to then transfer that heat to the internal steel belts and bead wires found in most modern tires. The tire's ability to absorb heat makes them more difficult to ignite than wood fires, but this same quality makes tire fires more difficult to extinguish than wood fires. Tire fires typically progress through three stages: the Incipient or Ignition and Propagation Stage; the Free Burning Stage; and the Smoldering Stage. The Free Burning Stage can be further separated into the Compression Stage and the Equilibrium and Pyrolysis Stage. Each of these stages is discussed below.

Ignition and Propagation Stage

Once a tire has ignited and a flame front has been developed, constant radiant heat flow will begin to affect the surrounding tires. It is generally accepted that tires will begin to decompose in the presence of radiant heat between 410°C and 538°C. An initial burn rate of approximately 2 square feet every five minutes in the windward direction is generally accepted for tire pile fires. The rate accelerates 50 percent after the first ten minutes of burn time. During this stage the fire has little forward and downward pressure as the surrounding tires are absorbing most of the heat.

Free Burning: Compression Stage

The flattening and shredding of tires as they begin to loose their shape and flatten into strips characterizes the beginning of the compression stage. Open flaming and forward pressure is produced during this stage with increased amounts of heat and smoke. The heat contributes to the collapse of the tires building downward pressure. At this point, in very large tire pile fires, the surrounding air cannot quickly absorb the heat from the fire. There is very little downward pressure since the tires are still mostly round and the fire is not deep-seated. The heat output is relatively low with incomplete and uneven combustion. With large, high-piled tire pile fires, inward collapse may begin within thirty minutes to one hour after initial ignition. With low-piled tire pile fires, much of the available fuel is consumed during the first hour and it may take several hours before the pile begins to collapse.

As a tire pile begins to collapse, a semi-solid mass of rubber, tire cords and steel is created and the open flame is slowed as the internal portions of the tire pile fire receives less air. At this point, equilibrium is starting to occur, which is the next stage of a tire fire.

Free Burning: Equilibrium and Pyrolysis Stage

A tire pile fire reaches equilibrium when the level of fuel conversion is approximately equal to the available amounts of heat, fuel, and oxygen. At this point the tire pile fire has low open surface flames with much of the fire deep-seated or internal. This results in very high internal temperatures (approximately 1,100°C) and slower and more complete fuel consumption.

Fire spread during this phase is influenced by the tire product configuration. Whole tire piles will tend to burn down into the middle of the pile because the shape of the tires allows heat and gas to rise vertically, bringing oxygen up with the cool air, through the pile from below. After whole tires have burned, the covering formed by the remaining steel cords effectively break-up water streams, producing steam before the water affects the burning tire pile. Fire tends to spread over the surface of shredded tire and crumb rubber piles. This results in a ceramic clay-like covering that deflects water and prevents water penetration from dousing the fire, allowing the internal fire to continue burning.

Pyrolysis is defined as a chemical change brought about by the introduction of heat. In tire pile fires this occurs when tires breakdown in the fire and release pyrolytic oil. Downward pressures then push this oil out of the fire. During a tire pile fire, the average passenger tire releases up to 2.0 gallons of pyrolytic oil.

Smoldering Stage

As tire pile fires burn during the smoldering stage, products of incomplete combustion are released. Of particular concern is pyrolytic oil, which will begin to pool and run-off and/or leach into the soil. It is possible for the heat from the tire pile fire to ignite the pyrolytic oil creating a secondary flowing oil fire. Other products of concern released during this stage of a tire pile fire include carbon monoxide, polynuclear aromatic hydrocarbons and volatile organic compounds. As the rate of propagation of the fire slows along the edges, the outer surfaces cool trapping intense heat internally. At this point it can be extremely hazardous to open up the fire, as emissions of fire gasses are released at a high rate and can flash up at high speeds as available oxygen increases.

Site Operators

Site operators provide the first line of defense at a tire pile site since they are usually onsite at the onset of a fire before emergency responders arrive. Site operators should be trained in tire fire prevention and initial response tactics for tire pile fires. This training should provide site operators a basic understanding of fire prevention measures, firefighting techniques, toxic effects of a tire fire, and the environmental issues that arise out of a tire pile fire. In addition, the owner/operator of the facility must be familiar with state and local Fire Department and Health and Safety Department codes. With sufficient training and knowledge, the staff at the facility has the ability to respond to a fire emergency in a prompt, positive, and effectively manage the emergency until fire fighters arrive on site.

Listed below are several fire prevention practices that each tire pile facility should adopt, to minimize the breakout of a large tire pile fire:

- Conduct a Fire Safety Audit;
- Appointment and Organization of Supervisory Staff;
- Develop Emergency Procedures;
- Fire Drill Procedures and Training;
- Maintenance of Building Facilities and Fire Protection Equipment;

- Alternate Measures for Temporary Shutdown of Fire Protection Equipment or Systems;
- Control of Fire Hazards;
- Maintaining Fire Department Access for Fire Fighting and Related Fire Suppression
- Preparing Schematic Diagrams and Site Plans; and
- Posting Emergency Procedures and Emergency Phone Numbers.

Fire Fighting Techniques

In general, the approach to fighting a tire pile fire is the same as fighting most other fires. The general approach includes the following:

- Rescue/Evacuation;
- Exposure Protection;
- Confinement;
- Extinguishment; and
- Overhaul.

In many other types of fires, the exposure, confinement, and extinguishment phases can occur almost simultaneously with good tactics of hose line placement. However, with tire fires, each phase of the fire must be completed before the next phase can begin. Until the exposure of unburned tires is removed, the fire cannot be contained, and until it is contained, it cannot be extinguished. Extinguishment must be complete before overhaul can begin because of the tendency for tires to retain heat and re-ignite. Tire fires rarely involve life-threatening rescue efforts, but many require evacuation of residential areas in the vicinity. The speed and direction of the wind will dictate the extent of evacuation, and conditions may change during the course of the tire fire, which may warrant a change in the evacuation plan. Evacuation efforts can often be delegated to police or other agencies.

HAZMAT Response

Due to the potential release of toxic chemicals, the first responders to the tire fire emergency should handle the fire as a HAZMAT incident with fire. The approach to the incident should be in accordance with tactics common to a hazardous materials response. Specifically, the response must be made Safely, Slowly and Methodically. The goals and priorities of the response must be:

1. Save lives and limit casualties
2. Protect the environment
3. Limit damage to property
4. Restore area to normal as soon as possible

Tire fires release chemicals into the air, soil, and water tables, which are hazardous to both onsite personnel and the downwind community. Standard HAZMAT procedures are to be implemented immediately to ensure public safety, safety for emergency personnel, site operators, and the environment. HAZMAT procedures follow the acronym “SIN” or

rather "SINCIAPCPDDD" as the basic initial on-scene actions at all tire fire incidents. Incorporating a tire fire into a HAZMAT response would include the following steps:

"S" Safety

The initial approach to the fire should be uphill, upwind and upstream at a safe distance so as to not be exposed to any hazard. Initial responders must take into consideration the current and expected weather and wind direction, and the local topography.

Personnel should also keep a safe distance from any scene thought to be unsafe because of criminal trespassers or hostile property owners. First responders need to assess the dangers of live wires, HAZMAT or environmental exposures and other possible complications. Other threats to firefighter safety include; tire pile instability, operations around heavy equipment and machinery, snakes and other wild animals living in the tire pile.

The incident commander should tour the site's perimeter (if possible) in order to view all angles of the fire, determine the location and rate of fire spread, amount of available fuel and the location of exposures. During this initial survey, a determination should be made whether any persons have been injured or if anyone at the site is in danger.

"I" Isolation

Tire pile fires, like any hazardous materials incidents, require that control zones be setup to minimize hazards to responding fire personnel, law enforcement, consultants, press, and the public. Control zones are those areas at a hazardous materials incident that are designated based upon safety and the degree of hazards. The most frequently used terminology for these zones are the hot, warm, and cold zones. These zones are described in more detail below.

- Hot Zone: The hot zone is the area immediately surrounding the tire pile fire, and extending far enough to prevent adverse effects from hazardous materials releases to personnel outside the zone. This zone is also referred to as the exclusion zone or restricted zone in other documents.
- Warm Zone: The warm zone or support zone is the area where personnel and equipment decontamination and hot zone support take place. It includes control points for the access corridor and thus assists in reducing the spread of contamination. This zone is also referred to as the decontamination, contaminant reduction, or limited access zone in other documents.
- Cold Zone: The cold zone contains the command post and other support functions that are deemed necessary to control the incident.

"N" Notifications

State and local emergency response teams should be a component to pre-planning. In the event of a tire fire, local fire fighting efforts for communities may not have sufficient resources to handle such an emergency. Pre-incident plans should contain up-to-date emergency contacts for all local, state, and federal agencies or organizations with expertise or responsibility in the management of environmental disasters. The lists should include phone numbers, facsimile numbers, addresses, and radio frequencies, if applicable. Since emergency management structures differ across state and county lines, each fire department will have to research its own government structure and laws to determine the appropriate agencies to involve. These agencies should participate in, or at least become familiar with, the pre-incident plans. Examples of concerned agencies would be:

- State and local Police;
- Public Works agencies;
- State Department of Emergency Management;

- Regional offices of the Federal Emergency Management Agency (FEMA);
- Regional, State or Federal Environmental Protection Agency (EPA);
- State Division of Natural Resources or State Forestry Agency;
- State Fire Marshals office; and
- Finance, Purchasing and Budget agencies.

"C" Command/Management

Command and Control actions should size up the incident; establish safety procedures and tactics to firefighting personnel; enhance safety decisions for the evacuation of local residents; and enhance decisions for the containment of toxins and the protection of the local environment.

The incident commander should not be reluctant to call in additional resources based on who is going to pay for the resource or services. Funding at the state and federal level will reimburse local cost.

In that so many disciplines will be involved in this emergency a systems approach or Unified Command will need to be established to insure that everyone's concerns are addressed and that communications between local, state, and Federal agencies are clear and consistent.

"I" Identification & Assessment

The combustion of waste tires result in the release of chemicals that are known or suspected carcinogens that can be absorbed through the skin, mucous membranes, or the respiratory system. Exposure hazards associated with tire fires can be introduced by the smoke plume (from the fire), water run off (from the water used to put out the fire), and soil contamination (from the oil and heavy metal products).

The by-products of a tire fire are smoke, pyrolytic oil, ash and carbon black. The first three pose a serious threat to first responders and the environment. Depending on how a fire is suppressed, the environmental concentrations will vary dramatically. Basically one can presume the following during a tire fire:

Smoke—VOCs, SVOCs, PAHs, particulate matter, heavy metals, carbon monoxide, sulfur and nitrogen oxides, and acid gasses.

Pyrolytic Oil—Petroleum hydrocarbons, VOCs, SVOCs, heavy metals.

Soil/Ash—*Heavy metals, sulfates, SVOCs, VOCs, petroleum hydrocarbons, dioxins, and furans.*

Information about tire fires in response guides is unusually limited given the occurrence and impact to communities and the environment. Although many of the chemicals released during a tire fire are listed, a tire is not list under the guide books. To assist the first responder the following mock-up NFPA Hazard Label (Health 3, Flammability 2, and Reactivity 1) was created to be used as a guide during a tire fire and is not intended as labeling for tire storage. Additional chemical information from tire fires are listed in the following table:

Environmental Contaminants	**Smoke**	**Ash/Soil**	**Pyrolytic Oil**
Acid Gasses	High	N/A	Low
Benzene	High	Low	Medium
1,3-Butadiene	High	Low	Medium
Other VOCs	High	Low	Medium
Benzoic Acid	Medium	High	Med/Low
Other SVOCs	Medium	Medium	Med/Low
Carbon Monoxide	High	N/A	N/A
Dioxins and Furans	Low	Low	Low
Lead (older tires contained lead oxide)	Medium	Med/High	Low
Zinc	Medium	High	Low
Other Heavy Metals	Medium	High	Low
PAHs	High	Low/Med	High
Sulfur Compounds	High	High	Med/Low

Table 8: Responder Table: Approximate Level of Contaminants for Tire Fire Byproducts

Note: This is only a quick guide and does not indicate the toxicity or hazards of each contaminants

NA = not applicable
VOCs = volatile organic compounds
SVOCs = semi-volatile organic compounds
PAHs = Polynuclear aromatic hydrocarbons
Hazardous substance associated with tire pile fires include:

Pyrolytic Oil: Pyrolytic Oil is free flowing oil that contains the following target compounds: Naphthalene, anthracene, benzene, thiazoles, amines, ethyl benzene, toluene, and various metals such as, cadmium, chromium, nickel and zinc.

Ash: Ash contains various heavy metals including lead, arsenic, and zinc.

Smoke: Smoke contains VOCs, SVOCs, PAHs, particulate metals, heavy metals, carbon monoxide, dioxins and furans, sulfur and nitrogen oxides, PCB's and acid gases (hydrochloric, and sulfuric). A list of target compounds includes:

"A" Action Planning

There are many issues that need to be considered during a tire fire event to manage the emergency. The primary goal is to protect human health. In the event of an emergency, the pre-incident plan should be used to guide initial actions. It should also be referred to when developing the Incident Action Plan, which is broad and encompasses all activities related to the incident. And finally, a Site Safety Plan should be developed which is a more detailed technical plan focusing on actions in the control zones. Depending on the site-specific pre-incident plan, the following firefighting techniques should be considered:

Personal experience of emergency responders to previous large tire pile fires has shown that fire exposure problems (e.g. unburned tires) may be the most important and difficult challenge to address during a fire incident. The exposure priority of burning tire products is usually accomplished by surrounding and/or isolating unburned tire piles. If the exposure can be eliminated, then the fire department has protected the exposure and contained the scope of the incident.

The initial stages of the fire are best spent on exposure control and containment of run-off oil and water. In many of the case studies, fire departments attempted to use water to confine and extinguish the fires with "surround-and-drown" tactics because the heavy equipment needed to move unburned tires was not immediately available. This practice only slows down the combustion process, creating more smoke, and does not effectively reduce the rate of spread or extinguish the fire. Water application is best used to keep unburned tires from burning rather than to extinguish the burning tires. Hose streams should only be used to protect unburned tire piles and other exposures like heavy equipment, buildings, and personnel.

Control Burn*:* This technique has been used to minimize hazardous water runoff and groundwater contamination. Allowing the fire to burn, while protecting the exposures, minimizes the impact on air pollution because the free-burning tire fire is in equilibrium and pyrolysis phase and will consume most of the fuel. Free burning therefore reduces toxic and carcinogenic combustion emissions such as benzo(a)pyrene and benzene, as well as toluene, chrysene, zinc oxide, titanium dioxide, carbon monoxide, sulfur dioxide, and hydrogen sulfide.

Containment: This technique consists of smothering the burning tire pile with dirt and is not recommended. Once smothered, the fire will continue to smolder for weeks or months and generate a con-

tinuous source of pyrolytic oil. It is also possible for the smoldering tire fire to periodically break out into open flames creating an unpredictable and hazardous environment for emergency personnel. Additionally, due to oil residues, this method can result in significant soil and water contamination.

Extinguishment: Water is generally utilized to fight Class A fires which include absorbent materials such as wood, paper, and cloth. By contrast, tires and shredded tires do not absorb water, but instead repel it. Experience at tire piles has shown that master water streams produce much greater runoff without significantly improving fire knock-down. Instead, fog streams may be more effective for dousing separated burning product piles (USFA, 1998). Fog streams are very effective in fighting shredded or crumb rubber pile fires.

At tire fire sites where water extinguishment has been successful, excavation equipment was used first to separate the burning materials into small manageable piles. The fire was doused with hand-lines, and a front-end loader was used to move the material to be submerged to complete the overhaul. It is important to keep heavy equipment cool and wet due to the extreme heat of a tire pile fire.

Other successful methods utilizing water include submerging burning rubber in water filled construction bins or ponds. It should be noted that after the material has cooled, the residual water must be tested for contaminants and, if necessary, shipped off site for hazardous disposal.

Foam Fire Suppressants:

Foam suppressants are most effective in extinguishing small tire fires. Heavy machinery is used to disseminate a larger tire pile into a smaller manageable fire. In this technique water is used to cool the fire, and then foam is used to douse the fire. Foam is particularly useful in suppressing oil fires that are common with tire fires (COSFM, 1995).

Class A Foam/ Wetting Agents

Class A foam is used to insulate unburned fuel. Class A wetting agents are designed to reduce surface tension to improve water penetration. These products have limited use and controversial effectiveness in tire fires. Like water, their best use is perhaps preventing ignition of unburned tires.

Class B Foam

According to the United States Fire Administration (USFA) special report on scrap and shredded tire fires (1998), the use of Class B Foam was not effective in extinguishing the fire in the ignition and propagation phases. Class B foams are traditionally used to fight two dimensional fuel fires. For this reason, Class B foams can be used to prevent ignition of run-off oil or to extinguish flaming pools of pyrolytic oil.

Non-Standard Firefighting Equipment

Because a tire pile fire is very different from a typical structure fire, non-standard fire fighting equipment is necessary to effectively combat the fire. This non-standard fire fighting equipment includes a variety of heavy equipment and HAZMAT trained equipment operators. Because tire pile fires typically meet the requirements for activation of state Environmental Protection Agency (EPA) assistance, the state EPA will usually provide contractors familiar with hazardous waste cleanup, and who have expertise and knowledge of excavation equipment. Heavy equipment can be also procured through a variety of means including county, state, and commercial suppliers. Counties often have heavy equipment in their highway departments including; excavators, bulldozers, front loaders, dump trucks, etc. At the state level, the California Department of Forestry (CDF) has heavy equipment with operators already trained in firefighting techniques. If these resources are not available, commercial suppliers can be contracted to provide necessary equipment and operators. It is the responsibility of the local fire authority to select the most appropriate route to procure heavy equipment and operators and to have an appropriate training plan in place to utilize these resources. Four types of equipment are usually needed on tire fires including excavators, bulldozers, front-end loaders and dump trucks. With these specialized machines, the operation can be more efficient and effective.

"P" Protective Equipment
Personal Protective Gear

Tire fires are hazardous and require dermal and respiratory protection for all personnel responding to and working in the vicinity of the tire fire. The use of personal protective gear is mandatory for tire fires. The local Incident Command and Control System and the pre-incident emergency plan should describe what level of personal protective equipment (PPE) is required for each phase of the emergency event. The following is a list of standard PPE:

- Helmet;
- Turnout Coat;
- Turnout Pants;
- Nomex Hood;
- Latex Gloves (to be worn under firefighter gloves to provide secondary protection against absorption of chemicals through wet gloves);
- Firefighting Gloves;
- Boots;
- Self contained breathing apparatus (SCBA) and
- Tyvex Suits (optional: to provide secondary protection against absorption of chemicals through primary protective clothing)

Additionally, due to other potentially hazardous components, the pre-incident plan should include PPE guidelines, NFPA guidelines and codes, OSHA directives for hazardous waste and emergency response standards described in 29 CFR 1910.120 and 29 CFR 1926.65, paragraph (q): *emergency response to hazardous substance releases*, and the United States Fire Administration Special Report on Scrap and Shredded Tire Fires (1998).

"C" Containment & Control

Experience of emergency responders to previous large tire pile fires has shown that fire exposure problems (e.g. unburned tires) may be the most important and difficult challenge to address during a fire incident. The exposure priority of burning tire products is usually accomplished by surrounding and/or isolating unburned tire piles. If the exposure can be eliminated, then the fire department has protected the exposure and contained the scope of the incident.

Minimizing the spread of a tire fire to unburned tires has many challenges including the following:

- Most tire piles are not adequately separated;
- Fire apparatus and heavy equipment access roads may be inadequate;
- Tire pile separation requires heavy equipment that may take substantial time to get on site and in operation;
- Even with large amounts of water, it is difficult to keep deep-seated tire fires from re-igniting and spreading from within the pile; and
- In the first 30 minutes of the fire, the fire spreads quickly, at a rate of approximately two square feet every five minutes.

All of the challenges can be managed through the development of an effective pre-incident plan. In many of the case studies, fire departments attempted to use water to confine and extinguish the fires with "surround-and-drown" tactics because the heavy equipment needed to move unburned tires was not immediately available.

Therefore, the initial stages of the fire are best spent on exposure control and containment of run-off oil and water. Water is best used to keep unburned tires from burning rather than to extinguish the burning tires.

Once adequate separation is obtained with excavators and bulldozers, an earthen berm can be built around the burning tire pile. The earthen berms should be at least one half the height of the tire pile, provided that the angle of repose of the pile is not such that material from the top can tumble out of the confining berm. With the berm complete, the tire fire can be considered contained and extinguishment can become the main focus.

A berm can also be used where adequate separation is not possible; NFPA recommends berms 1 1/2 times the tire pile height. However, because heavy equipment and loads of earth must be moved into position to build berms, it is difficult to accomplish this if adequate separation is not available during a fire.

"P" Protective Actions

During the initial response to a tire pile fire, it is essential that the threat to the surrounding community be assessed quickly. The incident commander should consider evacuation of civilians, as a life safety consideration. No strategy for managing the incident should by-pass evacuation considerations. Since burning tires are extremely difficult to extinguish, the incident commander should make early evacuations a high priority.

Nearby homes, commercial buildings or public places should be considered for evacuation depending on the amount and direction of the smoke plume. Any area likely to be contacted by direct smoke should be evacuated as a precaution. Consider closing roads or transportation routes affected by thick smoke.

Areas identified for potential evacuation during the pre-incident planning process, including any area exposed to the smoke plume, or subject to such exposure from shifting winds, should be evacuated as a precaution. The staging locations for evacuees should be identified during the pre-incident planning process. The time needed to conduct the evacuations in an orderly manner should be considered and factored into calculations for transportation requirements.

Liaison with law enforcement and emergency preparedness organizations will be necessary to facilitate this activity. Medical and health care agencies should also be involved to assist the elderly, especially if the evacuation time is prolonged.

No evacuees should be allowed to return to the vicinity until environmental monitoring has been performed by the appropriate authorities and the area is deemed safe and habitable.

"D" Decontamination & Cleanup

Decontamination or contaminant reduction is the physical and/or chemical process of reducing and preventing the spread of contamination from persons and equipment used within the hot zone of the tire pile fire. Decontamination takes place within the "Warm Zone" or "decontamination area".

At every incident involving hazardous materials, there is a possibility that personnel, their equipment, and members of the general public will become contaminated. The contaminant poses a threat, not only to the persons contaminated, but also to other personnel who may subsequently come into contact with the contaminated personnel and equipment. The entire process of decontamination should be

directed toward confinement of the contaminant within the hot zone and the decontamination corridor to maintain the safety and health of response personnel, the general public, and the environment. Sound judgment should be exercised and the potential effects of the decontamination process upon personnel should be considered when developing the decontamination plan.

Although decontamination is typically performed following exit from the hot zone, the determination of proper decontamination methods and procedures needs to be considered before the incident, as part of the overall pre-incident planning and hazard and risk evaluation process. No entry into the hot zone should be permitted until appropriate decontamination methods are determined and established based on the hazards present, except in those situations where a rescue may be possible and emergency decontamination is available.

Emergency response personnel should have an established procedure to minimize contamination or contact, to limit migration of contaminants, and to properly dispose of contaminated materials. The primary objective of decontamination is to avoid becoming contaminated or contaminating other personnel or equipment outside of the hot zone. If contamination is suspected, decontamination of personnel, equipment, and apparatus should be performed.

If personnel display any symptoms of heat exhaustion or possible exposure, appropriate emergency measures need to be implemented to doff PPE, while protecting the individual from contaminants and preventing the spread of any contaminants. These individuals should be transferred to the care of emergency medical services personnel who have completed training in accordance with applicable standards (e.g., NFPA 473, Standard for Competencies for EMS Personnel Responding to Hazardous Materials Incidents).

A debriefing should be held for those involved in decontamination as soon as practical. Exposed persons should be provided with as much information as possible about the delayed health effects of the hazardous materials involved in the incident. If necessary, follow-up examinations should be scheduled with medical personnel.

Exposure records should be maintained for future reference by the individual's personal physician and employer. This will help to provide early recognition and treatment of personnel with adverse physiological responses as a result of on scene activities.

"D" Disposal

The role of the emergency responders in this phase is usually limited to support in the form of exposure protection. Tires, metal, and other hazardous and non-hazardous debris from a tire fire burn site must be disposed of at a site approved by the CIWMB. As described previously in this report, significant quantities of pyrolytic oil are also generated during a tire fire pile. Previous experience at tire fire piles has indicated that the pyrolytic oil can be recycled at several types of reclamation plants.

These plants include:

1) petroleum refinery for re-processing into a fuel oil product;

2) authorized oil recycler for blending into a supplemental fuel;

3) at tire manufacturer plants for use in making new tire products and;

4) an asphalt plant for use as an oil supplement in making asphalt products. Previous experience has shown that disposal of the oil at any of the above facilities would be at no cost to the state.

However, recycling of pyrolytic oil is discouraged in the State of California, because the California Environmental Protection Agency (Cal-EPA) classifies pyrolytic oil as a "hazardous waste" under California's hazardous waste regulations. Instead, pyrolytic oil must be sent to an oil recycling facility. The cost of recycling pyrolytic oil is significant with a cost generally greater than $1 per gallon.

Discussions should be continued with the Department of Toxic Substances Control to allow for a variance or exclusion to the hazmat classification for materials generated during a tire pile fire, similar to those granted for petroleum producers.

The overall costs of site remediation is extremely high. The tire fire in Westley, California was $15 million and for Tracy, California $12 million to complete the site clean-up. Compared to fire suppression costs, $2.5 million for Westley and $450,000 for Tracy site remediation is not an obligation that local government will want to absorb.

"D" Documentation

This final section describes documentation and preparation of reports. This is one of the most critical steps in the entire tire pile fire process, because the words chosen in the report will act as the "final word" on the activities that took place during the fire event. This report will be thoroughly reviewed and dissected by a variety of interested parties ranging from government officials to investigators representing private parties.

Documentation of site activities, chronologies of events, and proper laboratory documentation, are all critically important during a tire fire. This information is not only necessary to assist the incident commanders and lead agency to determine if the response is effective, but also to be able to accurately present information to the press, public, and government agencies. A well documented chronology of events, combined with laboratory data, with properly completed chain-of-custody documentation (including sample date and time), is crucial to dissemination of the information to nearby residents and business owners who have been exposed to contaminants from the fire. In many instances, this data will alleviate fears of nearby residents who may be in the vicinity of a billowing smoke cloud, and provide the responding agencies authoritative and legally defensible data describing the exposure levels to residents, workers, and firefighters.

Documentation that should be included in the report includes: extinguishment methods used and the results associated with each, field notes, pictures, etc., air sampling data from offsite sources and downwind stations, and QA/QC (sampling) procedures. Additionally, soil and water quality data from both on and offsite locations should also be documented in the report.

At the completion of fire-fighting efforts, the lead agency should prepare and publish a detailed report which at a minimum includes the following information: 1) Site Background; 2) Fire Cause and Tire Fire Dynamics; 3) Potential Threats; 4) Agency Response and Unified Command Structure; 5) Fire Suppression Tactics, 6) Health and Safety; 7) Environmental Sampling and Monitoring; and 8) Preliminary Site Assessment Results, if available.

The report should also contain a section that presents in an objective manner lessons learned during the tire fire event. The purpose of this review is to determine what approaches and tactics worked well, and which did not. At a minimum, the lessons learned analyses should include the following components of a tire fire response:

- Incident Command System/Unified Command;
- Federal, State, and Local Coordination;
- Fire Suppression Tactics;
- Public Relations;
- Health and Safety;
- Environmental Effects and Concerns;
- Regulations, Policy, and Research Needs; and
- Problems Associated with Multi-Agency Response and Coordination.

Summary

Clearly there is an expectation that small rural fire departments, many of whom are already cash-strapped, will be overwhelmed if the large tire pile in their jurisdiction catches on fire. But with careful preplanning along with a solid hazardous materials response plan, most agencies can keep the damage of a tire fire to a minimum until state and federal resources arrive to help mitigate this long term emergency.

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