BLUE RIDGE ENVIRONMENTAL DEFENSE LEAGUE

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July 29, 2003
1828 Brandon Ave. SW
Roanoke, VA 24015

Douglas Edwards
West Central Regional Office
Department of Environmental Quality
3019 Peters Creek Road
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dredwards@deq.state.va.us

Dear Mr. Edwards:

Comments regarding the Draft Air Permit for Tire Energy Corporation, Registration No. 21415, Martinsville/Henry County, Virginia

I submit comments on behalf of both the Board of Directors of the Blue Ridge Environmental Defense League (BREDL) and Citizens For a Clean Environment (CFCE). BREDL is a regional, community-based, non-profit environmental organization. Our founding principles are earth stewardship, environmental democracy, social justice, and community empowerment. BREDL has chapters throughout the Southeast, including Virginia. CFCE is a BREDL chapter based in Martinsville and Henry County.

These comments are supplemental to comments provided at the July 14, 2003 Public Hearing. BREDL and CFCE may submit additional comments. All comments should be accepted.

We contend that Virginia DEQ's Draft permit for the TEC tire incinerator is woefully inadequate to protect citizen's health, safety, convenience and general welfare. We stress that this combustor is based on a new design that has yet to be proven! We can only hope that it can live up to all the promises. DEQ has the authority and the obligation to provide a more stringent permit. A permit based on real limits, not exaggerated cushion zones. A permit based on reality not promises. A permit that can properly protect citizens.
We hereby request that DEQ not approve this permit as drafted.

Tire Burning

Tires are composed approximately of 85 percent carbon, 10 – 15 percent ferric material, and 0.9 – 1.25 percent sulfur. Tires as fuel have been estimated, percentage by weight, as

having 89.51 percent carbon, 7.59 hydrogen, 0.27 nitrogen, 1.92 sulfur, 0.07 percent chlorine and 4.2 percent ash.

EPA research as found in its document “Air Emissions From Scrap Tire Combustion”, EPA-600/R-97-115, October 1997 has targeted 34 compounds that are emitted from burning tires and pose the greatest health risk from inhalation. EPA found that air emissions from open burning of tires include "criteria" pollutants, such as particulates, carbon monoxide (CO), sulfur oxides (SOx), oxides of nitrogen (NOx), and volatile organic compounds (VOCs). They also include "non-criteria" hazardous air pollutants (HAPs), such as polynuclear aromatic hydrocarbons (PAHs), dioxins, furans, hydrogen chloride, benzene, polychlorinated biphenyls (PCBs); and metals such as arsenic, cadmium, nickel, zinc, mercury, chromium, and vanadium. In open fire situations, these emissions can represent significant acute (short term) and chronic (long-term) health hazards to firefighters and nearby residents. These health effects include irritation of the skin, eyes, and mucous membranes, central nervous system depression, respiratory effects, and cancer.

While this facility may not be an open burn situation, it’s not a windmill either. We contend that DEQ must shoulder the burden of proof that this facility will not pose a health risk to citizens. DEQ needs to properly test, model and analyze ambient air concentrations for these target pollutants. DEQ needs to properly set limits that better reflect emissions. DEQ should not turn a waste problem into an air pollution problem.

Comments Deadline

Since both the legal notice published in the Sunday, June 29, 2003 edition of the Martinsville Bulletin and the notice attached to the Draft permit that BREDL received in the U.S. mail stated “Written comments will be accepted until 4:30 P.M. on July 31, 2003”, BREDL reserves the right to submit additional comments up to 4:30 PM on July 31, 2003. DEQ should accept any citizen comments submitted up to 4:30 PM on July 31, 2003.

Experimental

This facility is an experimental facility. There is no SIC code dedicated to such a facility. The necessary equipment has never been manufactured. The applicant stated that this will be a unique, patented design rotary tire combustor, which does not fall under any Code A equipment classification. Thus they classified it under the generic Code 99 other category. We contend that DEQ is permitting on blind faith, which may significantly impact the health, safety and general welfare of citizens of Virginia.

The EPA document “Air Emissions From Scrap Tire Combustion”, EPA-600/R-97-115, October 1997 points out that “Very little data exist for devices that are not well-designed and use scrap tires for fuel. These sources include fireplaces, wood stoves, small kilns, small incinerators, or any device with poor combustion characteristics. Air emissions from these types of devices are likely between that of open burning and a combustor.

However, there is serious concern that the emissions are much more similar to those of an open tire fire than a combustor."

The EPA document further states that "The results of a laboratory test program on controlled burning of tire-derived fuel (TDF) in a Rotary Kiln Incinerator Simulator (RKIS) are presented. Based on the results of the RKIS test program, it was concluded that, with the exception of zinc emissions, potential emissions from TDF are not expected to be very much different than from other conventional fossil fuels, as long as combustion occurs in a well-designed, well-operated, and well-maintained combustion device."

Both TEC and DEQ have likened this facility as being similar to a coal-fired plant. Considering the well-known harmful health impacts attributed to coal-fired power plants, that is not a very reassuring point. EPA research into tire emissions has found that "No data were available for poorly designed or primitive combustion devices with no add-on controls. Air emissions from these types of devices would depend on design, fuel type, method of feeding, and other parameters. There is serious concern that emissions would be more like those of an open tire fire than a well-designed combustor. Stack emissions test data would need to be collected and analyzed to confirm this." While this facility will have a few add-on controls, it is clearly evident that the entire process needs to be well-tuned with no leeway for poorly-designed or poorly-operating equipment.

The applicant stated that the ultimate analysis was based on several internet sources, yet failed to cite the sources. TEC further mentions that its analysis is based on shredded TDF. EPA research has shown that there is a difference between burning shredded and chunk (close to whole) tires. EPA research has shown that chunk sized tires emit more pollutants than shredded tires. EPA documents state that "The amount and type of processing/sizing that is used to convert a scrap tire to TDF. Size of TDF (whole tires, chunk, shredded, or crumb rubber) and type (wire-included or de-wired) influences the rate and type of air emissions."

Permitting the non-existent

Draft permit requirement #1 - Application: If this facility is indeed is to be operated "as represented in the permit application", then it will never be operational because the equipment does not exist. Requirement #1 further requires "any changes in the permit application specifications...which alter the impact of the facility on air quality may require a permit." Without the equipment being manufactured and provided in the Draft permit, then we contend that the permit should contain a reopening clause for when the equipment has been built and its specifications known.

Draft permit requirement #2 – Equipment List: On December 17, 2002 Virginia DEQ in Roanoke met with representatives of Tire Energy Corporation. DEQ meeting notes implied that TEC was still shopping around for a rotary kiln. The notes said there was "…a rotary kiln in Redding PA that Larry looked at." By the January 30, 2003 TEC application to DEQ, the rotary tire combustor is listed as "not yet manufactured". On

July 3, 2003, I visited the Roanoke DEQ office to look at the files for the TEC facility. I did not find any evidence that a specific rotary kiln has been identified for construction or purchasing. In the Draft permit for TEC, Item 2 Equipment List, the equipment list still does not identify a manufacturer. The equipment list is vague by only listing the rating for the rotary kiln, heat recovery system, heat exchanger and baghouse. Per 9 VAC 5-80-850 F., operating permits may contain, but not be limited to, several elements as necessary to ensure that the permits are enforceable as a practical matter. This permit should not be granted until the manufacturers of the main processing equipment, including rotary kiln, after burner, and steam boiler, have been properly identified.

TEC is making promises and DEQ is permitting these promises based on something that has never existed. This uniquely designed tire combustor is needed to form the basis of the permit. It has been the public relations selling point for this facility. Therefore, the specifications need to be known and included in the permit.

Permitting in phases

While both the application and the draft permit do not mention any phase development for this facility, there are some notations of concern.

DEQ notes from the December 17, 2003 meeting with TEC contained references to "phase 1 concept". Information that is posted on the company's website http://www.tires2steam.com/, mentions that their patented technology can be incorporated into either a "steam plant or as an integrated heat/steam source."

We point out that per 9 VAC 5-80-1140 C, "For projects with phased development, a single application should be submitted covering the entire project."

Emergency Bypass

Draft permit requirement #4 – Emergency Bypass Stack Cap: When the Bypass stack cap is open, a huge amount of criteria and hazardous air pollutants will escape into the ambient air. These emissions will be close to the toxic emissions that have been well-documented coming from open, non-controlled tire burning. Prior to the baghouse, which is after the bypass, TEC provides these figures:

Pollutants	Lbs/hr
CO_2	7,166
SO_2	48
HCL	1.74
NOx	1.90
N_2	49,943
Particulate	20

These figures do not take into account the incomplete combustion releases that would occur should the emergency bypass open.

As part of the monitoring requirements for the emergency bypass stack cap, per 9 VAC 5-170-160, we request that Virginia DEQ, the local Health Department, and the Martinsville Public Works Department be immediately notified whenever the bypass is open for 10 minutes in any 1 hour timeframe. This should be any combination of 10 minutes within a 1 hour timeframe, not necessarily consecutive 10 minutes. Considering that in just over 8 minutes of the bypass being open, the facility will exceed the 2.3 lb/hr limit for particulates based only on the pre-baghouse figures. This does not include particulates and other toxins that would escape from incomplete combustion. Permit requirements #32 and #33 need to be more restrictive.

Tire Storage

Draft permit requirement #7– Tire Storage: We commend both TEC and DEQ for requiring that the tires be stored in trailers and not in piles on the ground. However, we contend that DEQ needs to provide further protection from possible accidents and criminal acts. Per 9 VAC 5-170-160, the amount of trailers storing tires must be limited on site. In addition, the trailers need to be properly spaced to avoid more than one trailer catching on fire. EPA documents when discussing tire piles recommend that fire breaks should be at least 18 m (60 ft) wide. On the company's website, they have posted this information: "The National Fire Protection Agency (NFPA) has published standards for storing tires. Rather than storing the tires in the open, we will be storing them in closed trailers. This measure allows us to keep the fire lines open and establishes physical fire barriers that go beyond the requirements set forth by the NFPA. - NFPA 231D Standard for Storage of Rubber Tires 1998 Edition." These limitations need to be included in the permit requirements.

We also request that an alternative plan to dispose of the on-site tires be included as a requirement in the permit. Tires-to-energy facilities have been few and far between. They have experienced a high possibility of financial troubles. We request such a plan as a public protection clause.

Pollution Controls

Per 9 VAC 5-80-850 F, we hereby request a permit provision for the limestone injection pollution control process. On page 5 of the January 30, 2003 applicant letter which accompanied the application form, the applicant states that the proposed system will incorporate a baghouse with dry lime injection. According to the application, the dry lime is injected into the duct upstream of the baghouse and neutralizes SO2 and HCL.

New Regulations/Requirements

Draft permit excludes incorporation of the National Emission Standards for Hazardous Air Pollutants for Industrial/Commercial/Institutional Boilers and Process Heaters as being promulgated. This is an excellent example of how Virginia DEQ has failed to adequately protect the citizens of Virginia by issuing a weak draft permit. When the state

of Tennessee was permitting this very facility in the summer of 2002, Tennessee included a provision to reopen and revise the permit once these new regulations are adopted. We hereby request that VA DEQ, per 9 VAC 5-80-1000 A., add to the draft the following provision:

> The permittee is placed on notice that the category of Industrial/Commercial/Institutional Boilers and Process Heaters (40 CFR 63 Subpart DDDDD) is scheduled for regulation under Section 112 of the Clean Air Act for promulgation of Maximum Achievable Control Technology (MACT). This permit may be reopened and revised to include additional applicable requirements.

We hereby request that this permit be amended with emission limits for Particulate Matter 2.5. Virginia is not taking the lead in listing PM 2.5 emissions in the draft permit. Now is the time to address the new Particulate Matter 2.5 standard. In a November 2002 letter from EPA to Regional Air Division Directors, the Agency "encourages States to take early action to reduce emissions of pollutants that cause violations of the NAAQS for ozone (the 8-hour standard) and PM 2.5 and that cause regional haze".

Section 129 of the Clean Air Act directed EPA to develop incinerator regulations. We understand that the part which would pertain to a facility like TEC would be under the commercial industrial solid waste section. However, the EPA regs excluded facilities because of heat recovery. EPA has been legally challenged over this exclusion. This issue will probably be decided in 18 months to 2 years. EPA is being challenged that this exemption is not provided for by Section 129 of the Act. If this legal outcome impacts the regulatory category for the TEC facility, then per 9 VAC 5-80-1000 A, the permit should be reopened.

Additional Operations/Emissions Limitations

The draft permit contains a provision, requirement #11, for the minimum temperature of the secondary chamber as it should. In addition to the secondary chamber requirement, we hereby request, per 9 VAC 5-50-260, a minimum temperature requirement for the rotary tire combustor. According to TEC documentation presented to Henry County Planning and Zoning and obtained by BREDL from DEQ files, TEC stated that the rotary kiln would operate at 1800 degrees F burning the entire tire including metal. This provision needs to be added to ensure the alleged benefits of the tire combustion process by having both a rotary kiln and after burner.

Draft permit requirement #13 – Fuel limit: Per 9 VAC 5-80-1000, we hereby request an additional provision for this permit requiring a reopen clause for any increase in the tons per year of tires combusted. In addition, we hereby request a provision for significant amendment and public participation be added to the permit. Any attempt at increasing the tonnage per year of tires combusted should not be considered a minor permit amendment without public participation. A request to increase tonnage per year of tires

must be considered a significant amendment procedure, per 9 VAC 5-80-990, thus invoking procedures for public participation per 9 VAC 5-80-1020.

DEQ has granted the applicant too much leeway in the tonnage amount in the draft permit. The applicant states that it expects to burn only 10,500 tons per year, yet DEQ has granted 13,140 tons per year in the permit. That is over a 20 percent cushion. A more reasonably lower fuel limit needs to be stated in the permit.

Spare Parts Inventory: Per 9 VAC 5-80-850 F.6 and 11., we hereby request that a spare parts inventory be included as a provision of this permit. This provision should include spare parts be kept on-site for the rotary kiln, secondary chamber (after burner), and all applicable pollution control equipment. We request this for the kiln and afterburner because this equipment in the operation allegedly acts as a pollution control by the high temperature combustion.

Draft permit requirement #17 – Emission Limits: The emission requirements are exceptionally weak in both the exclusion of hazardous air pollutants and the granted leeway in emissions for the pollutants that are listed.

Both TEC and DEQ have claimed that the burning process and pollution controls will prevent almost all of the HAPS and particulate pollution from this facility. One of the selling points was that the baghouse would be equal to or greater than 99 percent effective at controlling particulates as stated in the January 30, 2003 applicant letter which accompanied the application form, page 4. In fact, TEC in its documentation to the Henry County Planning and Zoning office was so bold as to say that the "bag house removes all remaining particles before going to the stack". Well, okay guys, its time to put these grandiose claims in the permit. Air modeling that was conducted by S&ME for TEC listed a 99 percent efficiency for particulates. However, the draft permit limit exceeds any leeway amount that could be somewhat understandable. The draft permit grants a limit that is 8.7 times more than the applicant says he needs. The draft permit limit would, in effect, demonstrate only an 88.5 percent pollution control efficiency of the baghouse. This emission limit for particulates needs to be lowered in the draft permit.

Along these same lines, the emission limit for SO2 goes well above and beyond what the applicant says can be controlled. The applicant modeled for an emission rate of 9.52 lbs/hr yet DEQ granted the applicant an emission rate of 18.3 lbs/hr, which is 48 percent higher.

It gets worse, the applicant modeled for a NOx emission rate of 1.9 lbs/hr and DEQ granted the applicant an emission rate over 58 percent higher at 4.6 lbs/hr.

We hereby request that the emission limits be significantly lowered to a more reasonable cushion level. We also request that the air modeling be recalculated to reflect the draft permit emission limits.

Air Modeling

We hereby request DEQ to do complete air modeling for this facility. DEQ failed to include modeling for hazardous air pollutants per Rule 6-5, 9 VAC 5-60-300, et seq. At the very least, a glance at the emissions that TEC provided to the Henry County PSA in 1996, obtained from DEQ files, should have prompted a determination of the listed pollutants. BREDL calculations based on Rule 6-5 and the ACGIH 1991-1992 Threshold Limit Values book, which we had to purchase, shows that several HAPs exceed the exemption formula. Arsenic, Lead, Selenium, and possibly Mercury exceeded the threshold. In addition, the non-HAPs of Aluminum, Barium, Copper and Silver exceeded the TLV thresholds. Per Rule 6-5, we hereby request that DEQ perform air modeling on these pollutants to determine impacts to ambient air concentrations. We note that metals, including zinc, have been shown to be an effective metal catalyst for dioxin and furan formation.

We further request that the 34 compounds highlighted by the EPA document "Air Emissions From Scrap Tire Combustion", EPA-600/R-97-115, October 1997 be included in air modeling to determine impacts to ambient air concentrations. DEQ should further compare and include pollutants that have been measured and contain permit limits at the now defunct Modesto Energy Company Westley, CA facility and the Exeter Energy Sterling, CT facility.

The air modeling that was completed by SM&E over concerns with the TEC's emission stack being in close proximity to the Martinsville City water tower attempted to address concerns about the water supply via the ambient air concentrations. This modeling should have been taken an additional step to calculate actual impacts to the water inside the water tank. We strongly urge a close monitoring and analysis of the water inside the tank to test for the presence or any increase in concentrations of known pollutants that are emitted from tire burning and to show compliance with the Virginia "State Water Control Law", Virginia State Code Title 62.1, Chapter 3.1. Modeled Ambient air concentrations for both criteria and HAPs should be calculated and converted to show impacts to drinking water inside the tank. Airflow inside the tank is not the same as outside. The air inside the tank will not be as diluted as outside air. Some contaminants, metals could stick to the insides of the tank and attach to water as tank levels rise and lower.

Ambient Air Testing

We hereby request that DEQ, per 9 VAC 5-80-1150 B.9. and/or 9 VAC 5-80-870, require a complete air analysis and air testing to measure air quality data (present ambient air concentrations) at the proposed site prior to construction. This analysis should include criteria and hazardous air pollutants which are known to be emitted from the burning of tires as listed in the EPA document "Air Emissions From Scrap Tire Combustion", EPA-600/R-97-115, October 1997. We hereby request that a permit provision be added to reflect this pre-construction analysis.

In addition, as a permit requirement, we hereby request per 9 VAC 5-80-880 and/or 9 VAC 5-50-30 that DEQ conduct a complete air analysis and air testing at the site to measure air quality data (ambient air concentrations) within 60 days after the facility has commenced operations. If within 60 days, the facility is not operating under normal operation conditions as proposed, then once the facility reaches normal operation a second complete air analysis should be completed. This analysis should include criteria and hazardous air pollutants which are known to be emitted from the burning of tires as listed in the EPA document "Air Emissions From Scrap Tire Combustion", EPA-600/R-97-115, October 1997. We hereby request that a permit provision be added to reflect this operation analysis.

Stack Test

We hereby request per 9 VAC 5-80-850 F.7. that DEQ require a complete stack test for criteria and HAPs. In a June 2, 2003 DEQ reply to Citizens For a Clean Environment questions regarding this facility, Air Permits Manager Dr. Michael Scanlan replied that "The Tire Energy facility will be subject to stack testing for criteria and hazardous air pollutants." Yet, the draft permit, requirement #23, only lists criteria pollutants for the initial stack test. Later, permit requirement #26 states that "upon request by the DEQ, the permittee shall conduct additional performance tests for PM-10, SO2, or other pollutants…to demonstrate compliance with the emission limits…" DEQ needs to require stack testing for specific HAPs and list these requirements in the permit.

Monitoring

Draft permit requirement #18 – CEMS: This requirement is very weak and limited to only SO2 and CO continous monitoring. We hereby request per 9 VAC 5-50-40, 9 VAC 5-170-160 that requirement #18 be strengthened to include all criteria and HAPs pollutants that are suspected to be emitted from this type facility. This should include, but not limited to, the targeted 34 compounds that EPA highlights as being emitted from tire burning.

Boiler for Energy Creation

DEQ has permitted this facility as a boiler for the production and distribution of steam for sale. What happens when there is no purchaser for the energy? If this TEC facility has no purchaser for its energy then how can the primary purpose, the energy aspect, of this incinerator be justified? When the steam produced for energy is not being used, then this facility should cease operating.

Emergency Plan

Per 9 VAC 5-80-820 and/or 9 VAC 5-20-10 C , we request an emergency plan be created prior to the commencement of operation and added to the permit as a requirement. This should include, but not limited to, immediate notification to the appropriate authorities

when emissions are bypassing pollution controls and appropriate actions to control fire in tire stockpiled trailers.

Health Impacts from Suspected Pollutants emitted from tire combustion

Please see attachment.

In Conclusion

The draft permit is exceptionally weak in requirements and inclusion of criteria and HAPs pollutants and limitations. The draft permit is not in the best interest of the public's health, safety and general welfare. We hereby request that DEQ not approve this permit as drafted.

Respectfully submitted,

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Health Impacts from Suspected Pollutants emitted from tire combustion

Information as listed in EPA proposed regulations for boilers:

Arsenic: Acute (short-term) high-level inhalation exposure to arsenic dust or fumes has resulted in gastrointestinal effects (nausea, diarrhea, abdominal pain), and central and peripheral nervous system disorders. Chronic (long-term) inhalation exposure to inorganic arsenic in humans is associated with irritation of the skin and mucous membranes. Human data suggest a relationship between inhalation exposure of women working at or living near metal smelters and an increased risk of reproductive effects, such as spontaneous abortions. Inorganic arsenic exposure in humans by the inhalation route has been shown to be strongly associated with lung cancer, while ingestion of inorganic arsenic in humans has been linked to a form of skin cancer and also to bladder, liver, and lung cancer. The EPA has classified inorganic arsenic as a Group A, human carcinogen.

Cadmium: The acute (short-term) effects of cadmium inhalation in humans consist mainly of effects on the lung, such as pulmonary irritation. Chronic (long-term) inhalation or oral exposure to cadmium leads to a build-up of cadmium in the kidneys that can cause kidney disease. Cadmium has been shown to be a developmental toxicant in animals, resulting in fetal malformations and other effects, but no conclusive evidence exists in humans. An association between cadmium exposure and an increased risk of lung cancer has been reported from human studies, but these studies are inconclusive due to confounding factors. Animal studies have demonstrated an increase in lung cancer from long-term inhalation exposure to cadmium. The EPA has classified cadmium as a Group B1, probable carcinogen. Note: Just 2 weeks ago, a study was released which linked short-term cadmium exposure to an increase in breast cancer.

Chromium: Chromium may be emitted in two forms, trivalent chromium (chromium III) or hexavalent chromium (chromium VI). The respiratory tract is the major target organ for chromium VI toxicity, for acute (short-term) and chronic (long-term) inhalation exposures. Shortness of breath, coughing, and wheezing have been reported from acute exposure to chromium VI, while perforations and ulcerations of the septum, bronchitis, decreased pulmonary function, pneumonia, and other respiratory effects have been noted from chronic exposure. Limited human studies suggest that chromium VI inhalation exposure may be associated with complications during pregnancy and childbirth, while animal studies have not reported reproductive effects from inhalation exposure to chromium VI. Human and animal studies have clearly established that inhaled chromium VI is a carcinogen, resulting in an increased risk of lung cancer. The EPA has classified chromium VI as a Group A, human carcinogen. Chromium III is less toxic than chromium VI. The respiratory tract is also the major target organ for chromium III toxicity, similar to chromium VI. Chromium III is an essential element in humans, with a daily intake of 50 to 200 micrograms per day recommended for an adult. The body can detoxify some amount of chromium VI to chromium III. The EPA has not classified chromium III with respect to carcinogenicity.

Hydrogen Chloride: Hydrogen chloride, also called hydrochloric acid, is corrosive to the eyes, skin, and mucous membranes. Acute (short-term) inhalation exposure may cause eye, nose, and respiratory tract irritation and inflammation and pulmonary edema in humans. Chronic (long-term) occupational exposure to hydrochloric acid has been

reported to cause gastritis, bronchitis, and dermatitis in workers. Prolonged exposure to low concentrations may also cause dental discoloration and erosion. No information is available on the reproductive or developmental effects of hydrochloric acid in humans. In rats exposed to hydrochloric acid by inhalation, altered estrus cycles have been reported in females and increased fetal mortality and decreased fetal weight have been reported in offspring. The EPA has not classified hydrochloric acid for carcinogenicity.
Lead: Lead is a very toxic element, causing a variety of effects at low dose levels. Brain damage, kidney damage, and gastrointestinal distress may occur from acute (short-term) exposure to high levels of lead in humans. Chronic (long-term) exposure to lead in humans results in effects on the blood, central nervous system (CNS), blood pressure, and kidneys. Children are particularly sensitive to the chronic effects of lead, with slowed cognitive development, reduced growth and other effects reported. Reproductive effects, such as decreased sperm count in men and spontaneous abortions in women, have been associated with lead exposure. The developing fetus is at particular risk from maternal lead exposure, with low birth weight and slowed postnatal neurobehavioral development noted. Human studies are inconclusive regarding lead exposure and cancer, while animal studies have reported an increase in kidney cancer from lead exposure by the oral route. The EPA has classified lead as a Group B2, probable human carcinogen.

Mercury: Mercury exists in three forms: elemental mercury, inorganic mercury compounds (primarily mercuric chloride), and organic mercury compounds (primarily methyl mercury). Each form exhibits different health effects. Various major sources may release elemental or inorganic mercury; environmental methyl mercury is typically formed by biological processes after mercury has precipitated from the air. Acute (short-term) exposure to high levels of elemental mercury in humans results in CNS effects such as tremors, mood changes, and slowed sensory and motor nerve function. High inhalation exposures can also cause kidney damage and effects on the gastrointestinal tract and respiratory system. Chronic (long-term) exposure to elemental mercury in humans also affects the CNS, with effects such as increased excitability, irritability, excessive shyness, and tremors. The EPA has not classified elemental mercury with respect to cancer. Acute exposure to inorganic mercury by the oral route may result in effects such as nausea, vomiting, and severe abdominal pain. The major effect from chronic exposure to inorganic mercury is kidney damage. Reproductive and developmental animal studies have reported effects such as alterations in testicular tissue, increased embryo resorption rates, and abnormalities of development. Mercuric chloride (an inorganic mercury compound) exposure has been shown to result in forestomach, thyroid, and renal tumors in experimental animals. The EPA has classified mercuric chloride as a Group C, possible human carcinogen.

Nickel: Nickel is an essential element in some animal species, and it has been suggested it may be essential for human nutrition. Nickel dermatitis, consisting of itching of the fingers, hand and forearms, is the most common effect in humans from chronic (long-term) skin contact with nickel. Respiratory effects have also been reported in humans from inhalation exposure to nickel. No information is available regarding the reproductive or developmental effects of nickel in humans, but animal studies have reported such effects. Human and animal studies have reported an increased risk of lung and nasal cancers from exposure to nickel refinery dusts and nickel subsulfide. Animal studies of soluble nickel compounds (i.e., nickel carbonyl) have reported lung tumors. The EPA has classified nickel refinery subsulfide as Group A, human carcinogens and nickel carbonyl as a Group B2, probable human carcinogen.

Information from Agency for Toxic Substances and Disease Registry:

Polycyclic aromatic hydrocarbons (PAHs): PAHs can enter your body through your lungs when you breathe air that contains them (usually stuck to particles or dust). PAHs can enter all the tissues of your body that contain fat. They tend to be stored mostly in your kidneys, liver, and fat. Smaller amounts are stored in your spleen, adrenal glands, and ovaries. PAHs are changed by all tissues in the body into many different substances. Some of these substances are more harmful and some are less harmful than the original PAHs. PAHs can be harmful to your health under some circumstances. Several of the PAHs, including benz[a]anthracene, benzo[a]pyrene, benzo[b]fluoranthene, benzo[j]fluoranthene, benzo[k]fluoranthene, chrysene, dibenz[a,h]anthracene, and indeno [1,2,3-c,d]pyrene, have caused tumors in laboratory animals when they breathed these substances in the air, when they ate them, or when they had long periods of skin contact with them. Studies of people show that individuals exposed by breathing or skin contact for long periods to mixtures that contain PAHs and other compounds can also develop cancer. The Department of Health and Human Services (DHHS) has determined that benz[a]anthracene, benzo[b]fluoranthene, benzo[j]fluoranthene, benzo[k]fluoranthene, benzo[a]pyrene, dibenz[a,h]anthracene, and indeno[1,2,3-c,d]pyrene are known animal carcinogens. The International Agency for Research on Cancer (IARC) has determined the following: benz[a]anthracene and benzo[a]pyrene are probably carcinogenic to humans; benzo[b]fluoranthene, benzo[j]fluoranthene, benzo[k]fluoranthene, and indeno[1,2,3-c,d]pyrene are possibly carcinogenic to humans; and anthracene, benzo[g,h,i]perylene, benzo[e]pyrene, chrysene, fluoranthene, fluorene, phenanthrene, and pyrene are not classifiable as to their carcinogenicity to humans. EPA has determined that benz[a]anthracene, benzo[a]pyrene, benzo[b]fluoranthene, benzo[k]fluoranthene, chrysene, dibenz[a,h]anthracene, and indeno[1,2,3-c,d]pyrene are probable human carcinogens and that acenaphthylene, anthracene, benzo[g,h,i]perylene, fluoranthene, fluorene, phenanthrene, and pyrene are not classifiable as to human carcinogenicity. Acenaphthene has not been classified for carcinogenic effects by the DHHS, IARC, or EPA.

Dioxins/furans (chlorinated dibenzo-p-dioxins (CDDs)): CDDs are a family of 75 different compounds commonly referred to as polychlorinated dioxins. These compounds have varying harmful effects. The CDD family is divided into eight groups of chemicals based on the number of chlorine atoms in the compound. Incineration is the primary current source of release of CDDs into the environment. CDDs are associated with ash generated in combustion and incineration processes. Emissions from incinerator sources vary greatly and depend on management practices and applied technologies.
CDDs are released into the air in emissions from municipal solid waste and industrial incinerators. If you breathe air that contains CDDs, the CDDs can enter your body through your lungs and pass into the blood stream, but we do not know how fast or how much of the CDDs will enter the blood stream. If you swallow food or water containing CDDs, most of the CDDs will enter your body and pass from the intestines to the blood stream. Smaller amounts of highly chlorinated CDDs will enter your body compared to the less chlorinated 2,3,7,8-TCDD. Once in your body, CDDs can be found in most tissues with the highest amounts found in the liver and body fat (adipose tissue). Body fat and possibly the liver can store CDDs for many years before eliminating them from the body. CDDs with chlorine atoms in the 2, 3, 7, and 8 positions and highly chlorinated dioxins, such as OCDD, are generally found in higher concentrations in the fat than other

CDDs. The Department of Health and Human Services (DHHS) has determined that it is reasonable to expect that 2,3,7,8-TCDD may cause cancer. The International Agency for Research on Cancer (IARC) has determined that 2,3,7,8-TCDD can cause cancer in people, but that it is not possible to classify other CDDs as to their carcinogenicity to humans. The EPA has determined that 2,3,7,8-TCDD is a probable human carcinogen when considered alone and when considered in association with phenoxy herbicides and/or chlorophenols. The EPA has determined also that a mixture of CDDs with six chlorine atoms (4 of the 6 chlorine atoms at the 2, 3, 7, and 8 positions) is a probable human carcinogen. The health effects of some CDDs have been extensively studied in animals. Some CDDs are much more toxic than others. 2,3,7,8-TCDD and, to a lesser extent, CDDs with five (penta) or six (hexa) chlorine atoms substituted in the 2, 3, 7, and 8 positions, are extremely toxic to animals. Other CDDs, which do not have chlorine atoms substituted in the 2, 3, 7, and 8 positions, are considered relatively less toxic compared to 2,3,7,8-TCDD. 2,3,7,8-TCDD has been the most extensively studied CDD and it has been shown to cause a large number of adverse health effects in animals.

Benzene: Benzene can enter your body through your lungs when you breathe contaminated air. It can also enter through your stomach and intestines when your eat food or drink water that contains benzene. Benzene can enter your body through skin contact with benzene-containing products such as gasoline. When you are exposed to high levels of benzene in air, about half of the benzene you breathe in leaves your body when you breathe out. The other half passes through the lining of your lungs and enters your bloodstream. Animal studies show that benzene taken in by eating or drinking contaminated foods behaves similarly in the body to benzene that enters through the lungs. A small amount will enter your body by passing through your skin and into your bloodstream during skin contact with benzene or benzene-containing products. Once in the bloodstream, benzene travels throughout your body and can be temporarily stored in the bone marrow and fat. Benzene is converted to products, called metabolites, in the liver and bone marrow. Some of the harmful effects of benzene exposure are believed to be caused by these metabolites. Benzene can cause cancer of the blood-forming organs. The Department of Health and Human Services (DHHS) has determined that benzene is a known carcinogen. The International Agency for Cancer Research (IARC) has determined that benzene is carcinogenic to humans, and the EPA has determined that benzene is a human carcinogen. Long-term exposure to relatively high levels of benzene in the air can cause cancer of the blood-forming organs. This condition is called leukemia. Exposure to benzene has been associated with development of a particular type of leukemia called acute myeloid leukemia (AML). Exposure to benzene may be harmful to the reproductive organs. Some women workers who breathed high levels of benzene for many months had irregular menstrual periods. When examined, these women showed a decrease in the size of their ovaries. However, exact exposure levels were unknown, and the studies of these women did not prove that benzene caused these effects. It is not known what effects exposure to benzene might have on the developing fetus in pregnant women or on fertility in men. Studies with pregnant animals show that breathing benzene has harmful effects on the developing fetus. These effects include low birth weight, delayed bone formation, and bone marrow damage.

Zinc: Inhaling large amounts of zinc can cause a specific short-term disease called metal fume fever. However, very little is known about the long-term effects of breathing zinc dust or fumes. Taking too much zinc into the body through food, water, or dietary supplements can also affect health. The levels of zinc that produce adverse health effects are much higher than the Recommended Dietary Allowances (RDAs) for zinc of

15 mg/day for men and 12 mg/day for women. If large doses of zinc (10-15 times higher than the RDA) are taken by mouth even for a short time, stomach cramps, nausea, and vomiting may occur. Ingesting high levels of zinc for several months may cause anemia, damage the pancreas, and decrease levels of highdensity lipoprotein (HDL) cholesterol. It is not known if high levels of zinc affect the ability of people to have babies or cause birth defects in humans.

Vanadium: If vanadium is in the air, you can breathe it into your lungs. Most of it leaves your body in the air you breathe out, but some stays in your lungs. The part that isn't breathed out can go through your lungs and get into your bloodstream. If you breathe large amounts of vanadium dusts for short or long periods, you will have lung irritation that can make you cough, and you can also have a sore throat and red irritated eyes. These effects stop soon after you stop breathing it. People who breathed 0.1 milligram (mg) of vanadium per cubic meter (m 3) of air for 8 hours coughed for about 1 week and had irritated eyes. No studies designed to look for cancer in laboratory animals exposed to vanadium were found. Some minor birth defects (such as slightly smaller offspring, offspring with broken blood vessels on parts of their bodies or chemical changes in their lungs) occurred when female rats drank vanadium in water when they were pregnant. We do not know if vanadium would cause birth defects in people because these effects may occur only in animals. Monkeys and rats that breathed the dusts of vanadium compounds had changes in the cells in the lungs.

Barium: Barium enters your body when you breathe air, eat food, or drink water containing barium. It may also enter your body to a small extent when you have direct skin contact with barium compounds. Barium that you breathe seems to enter the bloodstream very easily. Barium does not seem to enter the bloodstream as well from the stomach or intestines. How much barium actually gets into your bloodstream depends on how much barium you breathe, eat, or drink and how easily the form of barium you breathe dissolves in the fluids in your body. Some barium compounds (for example, barium chloride) can enter your body through your skin, but this is very rare and usually occurs in industrial accidents at factories where they make or use barium compounds. The health effects of the different barium compounds depend on how well the specific barium compound dissolves in water. For example, barium sulfate does not dissolve well in water and has few adverse health effects. Doctors sometimes give barium sulfate orally or by placing it directly in the rectum of patients for purposes of making x-rays of the stomach or intestines. The use of this particular barium compound in this type of medical test is not harmful to people. Barium compounds such as barium acetate, barium carbonate, barium chloride, barium hydroxide, barium nitrate, and barium sulfide that dissolve in water can cause adverse health effects. Most of what we know comes from studies in which a small number of individuals were exposed to fairly large amounts of barium for short periods. Eating or drinking very large amounts of barium compounds that dissolve in water may cause paralysis or death in a few individuals. Some people who eat or drink somewhat smaller amounts of barium for a short period may potentially have difficulties in breathing, increased blood pressure, changes in heart rhythm, stomach irritation, minor changes in blood, muscle weakness, changes in nerve reflexes, swelling of the brain, and damage to the liver, kidney, heart, and spleen. The Department of Health and Human Services, the International Agency for Research on Cancer, and EPA have not classified barium as to its carcinogenicity.

Aluminum: Aluminum cannot be destroyed in the environment. It can only change its form or become attached or separated from particles. Aluminum particles released from

power plants and other combustion processes are usually attached to very small particles. Aluminum contained in wind-borne soil is generally found in larger particles. Exposure to aluminum is usually not harmful. Aluminum occurs naturally in many foods. Factory workers who breathe large amounts of aluminum dusts can have lung problems, such as coughing or changes that show up in chest X-rays. The use of breathing masks and controls on the levels of dust in factories have eliminated this problem Some workers who breathe aluminum dusts or aluminum fumes have decreased performance in some tests that measure functions of the nervous system Some people who have kidney disease store a lot of aluminum in their bodies. Some studies show that people exposed to high levels of aluminum may develop Alzheimer's disease, but other studies have not found this to be true.

Copper: Copper can enter your body when you drink water or eat food, soil, or other substances that contain copper. Copper can also enter your body if you breathe air or dust containing copper. Copper may enter the lungs of workers exposed to copper dust or fumes. Copper rapidly enters the bloodstream and is distributed throughout the body after you eat or drink it. Copper is essential for good health. However, exposure to higher doses can be harmful. Long-term exposure to copper dust can irritate your nose, mouth, and eyes, and cause headaches, dizziness, nausea, and diarrhea. If you drink water that contains higher than normal levels of copper, you may experience vomiting, diarrhea, stomach cramps, and nausea. Intentionally high intakes of copper can cause liver and kidney damage and even death. We do not know if copper can cause cancer in humans. EPA has determined that copper is not classifiable as to human carcinogenicity.

Silver: Since at least the early part of this century, doctors have known that silver compounds can cause some areas of the skin and other body tissues to turn gray or blue-gray. Doctors call this condition "argyria." Argyria occurs in people who eat or breathe in silver compounds over a long period (several months to many years). A single exposure to a silver compound may also cause silver to be deposited in the skin and in other parts of the body; however, this is not known to be harmful. It is likely that many exposures to silver are necessary to develop argyria. Once you have argyria it is permanent. However, the condition is thought to be only a "cosmetic" problem. Most doctors and scientists believe that the discoloration of the skin seen in argyria is the most serious health effect of silver. Exposure to dust containing relatively high levels of silver compounds such as silver nitrate or silver oxide may cause breathing problems, lung and throat irritation and stomach pain. No studies of cancer or birth defects in animals from eating, drinking, or breathing in silver compounds were found. Therefore, it is not known if these effects would occur in humans.

Naphthalene: Naphthalene is a white solid that evaporates easily. It is also called mothballs, moth flakes, white tar, and tar camphor. Exposure to a large amount of naphthalene may damage or destroy some of your red blood cells. This could cause you to have too few red blood cells until your body replaces the destroyed cells. This problem is called hemolytic anemia. Some of the symptoms that occur with hemolytic anemia are fatigue, lack of appetite, restlessness, and a pale appearance to your skin Exposure to a lot of naphthalene may cause nausea, vomiting, diarrhea, blood in the urine, and a yellow color to the skin. The carcinogenicity (cancer causing ability) of naphthalene has not been determined. The Department of Health and Human Services (DHHS) has determined that naphthalene may cause cancer in female mice but not in male mice or rats of either sex. The International Agency for Research on Cancer

(IARC) has determined that naphthalene is not classifiable as to its carcinogenicity to humans. The EPA has determined that naphthalene is not classifiable as to its carcinogenicity to humans.

Formaldehyde: Formaldehyde is irritating to tissues when it comes into direct contact with them. Some people are more sensitive to the effects of formaldehyde than others. The most common symptoms include irritation of the eyes, nose, and throat, along with increased tearing, which occurs at air concentrations of about 0.4–3 parts per million (ppm). NIOSH states that formaldehyde is immediately dangerous to life and health at 20 ppm. One large study of people with asthma found that they may be more sensitive to the effects of inhaled formaldehyde than other people; however, many studies show that they are not more sensitive. Severe pain, vomiting, coma, and possible death can occur after drinking large amounts of formaldehyde. Skin can become irritated if it comes into contact with a strong solution of formaldehyde. Several studies of laboratory rats exposed for life to high amounts of formaldehyde in air found that the rats developed nose cancer. Some studies of humans exposed to lower amounts of formaldehyde in workplace air found more cases of cancer of the nose and throat (nasopharyngeal cancer) than expected, but other studies have not found nasopharyngeal cancer in other groups of workers exposed to formaldehyde in air. The Department of Health and Human Services (DHHS) has determined that formaldehyde may reasonably be anticipated to be a human carcinogen (NTP). The International Agency for Research on Cancer (IARC) has determined that formaldehyde is probably carcinogenic to humans. This determination was based on specific judgements that there is limited evidence in humans and sufficient evidence in laboratory animals that formaldehyde can cause cancer. The Environmental Protection Agency (EPA) has determined that formaldehyde is a probable human carcinogen based on limited evidence in humans and sufficient evidence in laboratory animals.

Polychlorinated biphenyls (PCBs): PCBs may be released into the environment by the burning of some wastes in municipal and industrial incinerators. Once in the environment, PCBs do not readily break down and therefore may remain for very long periods of time. They can easily cycle between air, water, and soil. PCBs can accumulate in the leaves and above-ground parts of plants and food crops. PCBs are taken up into the bodies of small organisms and fish in water. They are also taken up by other animals that eat these aquatic animals as food. PCBs especially accumulate in fish and marine mammals (such as seals and whales) reaching levels that may be many thousands of times higher than in water. PCB levels are highest in animals high up in the food chain. Health effects that have been associated with exposure to PCBs in humans and/or animals include liver, thyroid, dermal and ocular changes, immunological alterations, neurodevelop-mental changes, reduced birth weight, reproductive toxicity, and cancer. Rats that ate food containing large amounts of PCBs for short periods of time had mild liver damage, and some died. Rats, mice, or monkeys that ate smaller amounts of PCBs in food over several weeks or months developed various kinds of health effects, including anemia, acne-like skin conditions, and liver, stomach, and thyroid gland injuries. Other effects caused by PCBs in animals include reductions in the immune system function, behavioral alterations, and impaired reproduction. Some PCBs can mimic or block the action of hormones from the thyroid and other endocrine glands. Because hormones influence the normal functioning of many organs, some of the effects of PCBs may result from endocrine changes. PCBs are not known to cause birth defects. Only a small amount of information exists on health effects in animals exposed to PCBs by skin contact or breathing. This information indicates that liver, kidney, and

skin damage occurred in rabbits following repeated skin exposures, and that a single exposure to a large amount of PCBs on the skin caused death in rabbits and mice. Breathing PCBs over several months also caused liver and kidney damage in rats and other animals, but the levels necessary to produce these effects were very high. Because the brain, nervous system, immune system, thyroid, and reproductive organs are still developing in the fetus and child, the effects of PCBs on these target systems may be more profound after exposure during the prenatal and neonatal periods, making fetuses and children more susceptible to PCBs than adults.