RHODE ISLAND LUNG ASSOCIATION

Monographs on
Occupational Health

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of
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series

WIRE and CABLE MANUFACTURING

Toxic Air Contaminants

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POTENTIAL HEALTH HAZARDS IN THE WIRE AND CABLE INDUSTRY

PROCESS	AGENT	HAZARD
Wire Drawing	Heavy reels of wire and cable	Back injury as the result of lifting or moving heavy reels
	Noise	Hearing Impairment
	Lubricants	Dermatitis
Tinning	Tin	Nondebilitating emphysema
Electroplating	Mists of acids and bases	Skin irritation and burns Lung irritation, inflammation, and possibly, bronchitis or permanent lung damage
Insulation of wire and cable with asbestos	Asbestos	Lung Cancer Lung Fibrosis (Asbestosis) Mesotheliomas (cancers on the membranes lining the lungs and abdominal organs)
Insulation of wire and cable with rubber and plastic compounds	Dusts and vapors from a variety of chemicals listed on pages 7-15.	Cancers and damage to various organs including lungs, liver, kidneys, and bladder due to inhalation, ingestion or absorption of chemicals through the skin.
Stripping of lead cables	Lead	Interference in the formation of red blood cells, anemia, gastrointestinal problems, central nervous system damage
Rubber dusting	Talc Asbestos Mica Zinc Stearate	Pulmonary Fibrosis Lung Cancer, Asbestosis, Mesotheliomas Pulmonary Fibrosis Pulmonary Fibrosis
Spark Testing	Ozone (low concentration) Ozone (high concentration)	Throat irritation, bronchitis Irreversible lung damage
Brazing	Brazing fumes from flux materials including fluorides, cadmium, zinc, copper, brass	Irritation of skin, eyes, and respiratory tract and possibly cancer Metal Fume Fever

Toxic Air Contaminant Hazards
Associated with the
Manufacture of Electrical Wire and Cable

INTRODUCTION

Many potentially hazardous chemicals are used in the manufacture of electrical wire and cable. The vast majority of these chemicals are employed in the production of rubber and plastic insulating materials. Because such a wide variety of wire and cable products is manufactured, it is not possible to talk in concrete terms about toxic chemical hazards throughout the industry. Each type of wire is manufactured to meet specific needs and can require the use of different compounds. Therefore, it is hoped that this report will serve as a general guide to potential air contaminant hazards and their control, as well as a starting point for further shop specific evaluation.

THE WIRE AND CABLE INDUSTRY IN RHODE ISLAND

Rhode Island has one of the highest concentrations of wire and cable firms in the United States. Its 12 firms manufacture a wide variety of wire and cable products including appliance wire, building wire, power transmission wire, underground cable, power supply cords, extension cords, heater cords, automotive wire, and telephone wire.

According to the Bureau of Labor Statistics, in 1980 approximately 5000 workers were employed in Rhode Island's electrical wire and cable firms, accounting for about 4% of the state's total manufacturing labor force. Most of the firms are unionized with the majority of workers belonging to either the International Brotherhood of Electrical Workers (IBEW) or the United Steel Workers of America (USWA).

OCCUPATIONAL INJURY AND ILLNESS DATA FOR RHODE ISLAND

One way to analyze the health status of wire and cable workers is to look at the Bureau of Labor Statistics' (BLS) occupational injury and illness data. This information must be carefully interpreted since it is widely recognized that many illnesses go unreported and are difficult to link to job conditions, while occupational injuries are much more obvious. BLS data is primarily useful in providing a relative comparison of injury rates among industrial categories.

Injury and illness data for 1980 showed that no work related illnesses were reported in Rhode Island's wire drawing industries. However, the number of workers who lost days due to work-related injuries was higher than for Rhode Island manufacturing industries in general, and for wire workers nationwide. In addition, injured workers were out about twice as many days as workers in the same industry nationwide, twice as many days as workers in manufacturing in Rhode Island, and about three times as many days as workers in manufacturing nationwide. Back injuries account for most of the lost time from work in the wire and cable industry.

STUDIES OF WORKER HEALTH

Very few studies have been conducted on the health of workers in the wire and cable industry. Those that have been done involved wire and cable firms in England. The major concern in these studies was the effect of exposure to a certain antioxidant containing alpha and beta naphthylamines used in the production of rubber insulated wire. Production of the antioxidant ceased in England in 1949. Neither alpha nor beta naphthylamine has ever been banned in the United States, although there has been no production of beta naphthylamine in the past 10 years. Alpha naphthylamine is still commercially available.

The early British studies revealed that rubber workers in both the rubber and cablemaking industries who were exposed to the antioxidant were at an increased risk for contracting and dying from tumors of the bladder. Today, both alpha and beta naphthylamine are regarded as bladder carcinogens.

While few studies have been conducted concerning the health of workers in the wire and cable industry, many studies have been done on workers in the rubber industry. In 1970, the United Rubber Workers Union contracted with six U.S. rubber companies to have comprehensive studies done to determine the adverse health effects of employment in the rubber industry. Since many of the chemicals that are used in the rubber industry are also used in the wire and cable industry, the results of these studies should be mentioned.

Studies conducted on workers in the rubber industry have shown that these workers experience excess deaths from certain types of cancers and from several other diseases. A review of the literature reveals a wide range of diseases associated with employment in the rubber industry including cancers of the bladder, prostate, cervix, lymphatic system, central nervous system, bowel, and stomach, as well as leukemia, heart disease and stroke.

It has been shown that for many of these diseases, workers employed in the rubber processing divisions are at the greatest risk. The processing divisions include rubber compounding, mixing, milling, extrusion, calendaring, cement mixing, and rubberized fabric operations. In general, rubber processing workers are at greatest risk for developing chronic respiratory disease, cancers of the stomach, large intestine, liver and biliary passages, as well as leukemia.

Rubber processing has been further broken down by researchers into front and back processing. A 1982 study showed that the risk for certain diseases is different depending on the division in which a worker is employed. Front processing workers are those who are involved in rubber compounding, mixing, and milling. They are at the greatest risk for cancers of the stomach and large intestine. Back processing workers are involved in extrusion, calendaring, cement mixing, and rubberized fabric operations. They have been found to be at greater risk for leukemia and emphysema.

Many of the diseases associated with employment in the rubber industry have long latent periods, meaning that it may take many years after an occupational exposure before a disease develops. For example, the latent period for prostate cancer is about 30 years. It has been determined that workers at the greatest risk for contracting prostate cancer were employed in the rubber industry between 1940 and 1947. Therefore, even though many potentially hazardous chemicals are no longer being used, workers exposed years ago may still be at risk for developing an occupationally-related disease as a result of past exposures.

It should also be noted that studies have shown that SMOKING INCREASES THE RISK OF OCCUPATIONALLY-RELATED LUNG DISEASES.

More research is needed to determine which chemicals used in the manufacture of rubber products are the cancer causing agents and whether or not employment in certain departments is actually causal.

WIRE AND CABLE MANUFACTURING PROCESSES

The following discussion examines the various processes involved in the manufacture of electrical wire and cable and highlights the major health hazards and methods of control associated with each.

WIRE DRAWING

In the wire drawing process, metal rods are reduced in diameter by pulling them through a series of industrial dies within a wire drawing machine. Often a series of machines containing dies of decreasing size is required to reduce the rods to wire of a desired thickness.

Rods usually consist of either copper or aluminum, however, alloys of other metals are occassionally used. Copper and aluminum as received at the wire and cable plant present few health hazards. Some sensitive individuals may develop dermatitis (a skin disorder) from handling copper rods, but this condition disappears when the exposure ceases. The wearing of gloves is an effective control measure.

There appear to be few problems in terms of chemical exposures during the wire drawing process. The only potential problem involves the use of lubricants in the wire drawing machines to facilitate passage of the wire through the dies. Lubricants are supplied in diluted form to each set of dies by pumping action from a central reservoir. It is unlikely, however, that enough of the lubricants would become airborne under normal operating conditions to cause any adverse health effects due to their inhalation. If inhaled in enough quantity, the fatty materials contained in some lubricants could cause lipoid pneumonia. Contact dermatitis, or skin irritation, is a possibility should the lubricants touch the skin. The wearing of gloves and regularly cleaned work clothing should prevent this problem.

NOISE

A major hazard involved in wire drawing, although not an air contaminant hazard, is noise. Excessive exposure to noise can cause permanent hearing impairment. Many plants have well over a hundred wire drawing machines which, without any controls, can produce noise levels well over the OSHA standard of 90 dBA averaged over an 8 hour day.

Noise levels can be reduced by fitting the machines with sound absorbing enclosures, especially around the gear boxes. In addition, metal gears can be replaced with nylon ones. If engineering controls are not sufficient and noise levels still exceed the standard, workers should be provided with some form of effective, yet comfortable, ear protection. It may be necessary to limit the amount of time each worker spends in noisy areas.

Pre-employment, as well as regular audiometric tests (hearing tests) should be performed to determine whether or not workers are experiencing any hearing impairment.

Other machines for which these controls might also be applicable include stranders and braiders which twist several strands of wire together to make thicker more pliable wire and cable.

BACK INJURIES

Another major hazard related to the wire drawing process, is the possibility of back injury from moving or redirecting heavy spools of wire by hand. Back injuries account for most of the lost work time associated with employment in the wire and cable industry.

Spools often weigh up to 1300 pounds and should be moved by forklift. Forklifts should operate on natural or liquid petroleum gas rather than gasoline or diesel fuel to avoid carbon monoxide build-up inside the plant. Carbon monoxide (CO) reduces the oxygen carrying capacity of the blood affecting the ability to think and perform manual tasks which can increase accidents. Inhalation of enough CO can result in death by asphyxiation.

Where spools must be redirected by hand, metal plates can be set into the concrete floor to make it easier for workers to move the spools. In parts of the plant where other heavy objects must be lifted and where forklifts are impractical, overhead mechanical hoists on ceiling tracks can be installed. Hoists that operate by suction can also be employed to lift heavy bags of chemicals.

TINNING AND ELECTROPLATING

Before copper wire can be insulated with natural or synthetic rubber, it is usually necessary to apply a separator between the wire and the insulation. Examples of separators include cotton, paper, and tin. The separator serves several purposes. It prevents the sulfur vulcanizing agent and other sulfur additives from tarnishing the copper and the copper from deteriorating the rubber insulation. The tin separator also facilitates subsequent soldering of the wire.

There are two methods of applying the tin separator on the wire: the "hot dip" method, and electroplating.

"HOT DIP" OR TINNING

The "hot dip" method requires passing the wire through a bath containing liquid flux and then through a bath of molten tin. Since the flux is not heated, there is little chance for it to become an air contaminant hazard. The tin, on the other hand, is heated enough to cause it to melt. While tin is not very toxic, the inhalation of tin fumes may cause the development of stannosis, usually a harmless accumulation of tin in the lung tissue. It is only rarely associated with localized emphysema, a non-debilitating destruction of air sacs.

Despite the lack of serious disease threat, local exhaust ventilation over the tin bath is recommended. Enclosing the bath with a hinged canope hood is the preferred method. This method also reduces energy costs by preventing heat from the bath from escaping into the workplace and makes the work environment more thermally comfortable.

Personal protective equipment should include face shield or goggles, leather apron, and leather boots to prevent the molten tin from coming in contact with the workers' eyes and skin.

Electroplating

In the electroplating process, wire is pulled through a series of chemical baths. Basic (or alkaline) and acid baths containing such potentially toxic compounds as sodium hydroxide, sulfuric acid, and hydrochloric acid, serve to clean the wire before it passes into the electroplating tank. Inorganic tin compounds including sodium stannate, stannous chloride, and stannous fluoride present in the electroplating tank provide the source of tin used to coat the wire.

Since all of the tanks are heated, fine airborne mists of acids, bases, and inorganic tin compounds are generated at their surfaces. Acids and bases are mucous membrane irritants affecting lungs as well as eyes. They may also cause skin irritation and burns. A major danger from repeated inhalation of these chemicals is inflammation of the delicate lung tissue that can, in time, lead to bronchitis or permanent irreversible lung tissue damage.

Inorganic tin compounds have not been found to cause systemic effects from occupational exposures, however, some can cause skin and eye irritation. This is primarily due to the production of acids and bases upon their reaction with water. Stannous chloride and water, for example, results in the formation of a strong acid, while sodium stannate and water results in the formation of a strong base.

Therefore, heated cleaning and electroplating tanks should be equipped with local exhaust ventilation. The use of antifoaming agents and surfactants can be used to reduce misting. In addition to adequate ventilation, the worker should be provided with a face shield or goggles, rubber gloves, rubber apron, rubber boots, and regularly cleaned work clothing in order to avoid any contact with the chemicals. Showering after each work shift is strongly recommended.

INSULATION OF WIRE AND CABLE

Wire and cable products are insulated with one of three types of materials: asbestos, rubber, and plastic.

ASBESTOS

Asbestos is the fibrous form of certain silicates. While not used quite as extensively now as in the past, it is still used by several firms as an insulating material for wire and cable products due to its noncombustible properties. Asbestos may also be found as a contaminant in some types of talc, a rubber dusting agent.

It cannot be emphasized enough that asbestos is a definite health hazard. In every major study of asbestos workers, exposure to asbestos, regardless of type, has produced excess mortality from lung cancer. The risk for lung cancer is the greatest among asbestos workers who smoke and appears to occur 10 to 20 years after the first exposure, peaking at about 30 years.

Exposure to asbestos has also been shown to cause asbestosis (lung fibrosis) as well as cancers on the membrane lining the lung (pleura) and abdominal organs (peritoneum) known as mesotheliomas. Symptoms of asbestosis include shortness of breath and some chest pain. A complete exposure history together with pulmonary function tests and a chest x-ray are required for diagnosis.

The control of worker exposure to asbestos is extremely important since reducing the exposure reduces the risk of developing an asbestos-related disease. Control of asbestos exposure should be aimed at the prevention of dust dispersion and include the enclosure of storage, weighing, and mixing operations. Local exhaust ventilation should be provided wherever asbestos may escape into the workplace. The use of face masks or air supplied respirators is recommended for high level exposures of short duration. Whenever asbestos is used, regular monitoring of dust levels should be done.

DEFINITIONS OF RUBBER AND PLASTIC MATERIALS

Rubber and plastic materials consist of natural and synthetic polymers which are organic compounds of high molecular weight made up of simpler molecules, or monomers bonded together. Both rubber and plastic compounds are technically considered plastic materials. Rubber is a thermosetting type of plastic material, while "traditional" plastics are thermoplastic materials. Thermosetting materials require heat in order to be formed into a permanent shape and may not be reshaped. Thermoplastics also require heat in order to be formed into shape, however, they may be resoftened and reshaped if heated again.

RUBBER AND PLASTIC COMPOUNDING

Before wire and cable products can be insulated with rubber and plastic compounds, many potentially toxic chemicals must be added to these basic compounds in order to make them more suitable as insulating materials. Most of these chemicals are in fine powder form and can present health hazards from inhalation or ingestion.

Many of these compounds have been shown to cause adverse health effects including irritation of eyes, respiratory tract, and skin, damage to lungs, liver, and kidneys, as well as cancers of various organ systems.

The processes of rubber and plastic compounding require that chemicals which are stored in bags, drums, and bins, be weighed, transferred, and dumped into large mixing machines. In the case of rubber compounding, the mixing machines are known as banburies. Plastic compounding is done in various types of equipment including plastificators. Many Rhode Island firms engaged in plastic insulating purchase premixed compounds from custom mixers, however, a few of the larger firms mix their own compounds.

Two opportunities exist for exposure to toxic chemicals during rubber and plastic compound mixing: 1) during the initial hand transfer of chemicals from storage containers to bins where they are weighed, and 2) when the contents of the bins are dumped into the top of the mixers.

Since weighing and dumping operations are quite dusty, weighing stations and mixing machines should have local exhaust ventilation. If particularly toxic chemicals must be scooped from bags or drums, workers should also wear the appropriate type of respirator.

The most effective way of reducing chemical exposures during rubber and plastic compounding operations is to pump chemicals directly from their storage containers into the mixing machines. In cases where this is not possible, conveyor systems which automatically dump chemicals into mixers is preferred over hand dumping.

In addition to engineering controls and the use of personal protective equipment like respirators, gloves, and aprons, a good way to minimize dust inhalation is to purchase and use additives in slab or oil-wetted form whenever available.

Because of the wide variety of toxic exposures during compounding, THERE SHOULD BE NO EATING OR SMOKING IN WORK AREAS. Clean work clothing should be used regularly, and showering before changing into street clothes is strongly recommended.

Listed below are examples of chemicals used within the wire and cable industry which fall into the various categories of rubber and plastic polymers and additives. Beside each chemical name is a short summary of its potential health effects. This list is by no means exhaustive, but it is hoped that it will be helpful in itself, and as a start for anyone wishing to further research health hazards associated with rubber and plastic compounding chemicals.

RUBBER POLYMERS AND ADDITIVES

Most rubber enters the wire and cable plant in neutral colored bales, some of it natural rubber, and some synthetic polymers such as acrylonitrile-butadiene, ethylene-propylene, and styrene-butadiene; polychloroprene or Neoprene ®, and Hypalon ® arrive in bags in the form of chips.

Many rubber monomers, including chloroprene and acrylonitrile are considered to be hazardous to human health and are regulated by OSHA. Since only the polymeric form of rubber compounds are used in the wire and cable industry and only trace amounts of monomer should remain, health hazards from rubber polymers are thought to be minimal. Residual monomer has been monitored in several firms and not found to be a problem. Still, more research is needed on the health effects of rubber polymers.

Before rubber can be used as an insulating material, it must be mixed with a variety of chemicals including fillers, pigments, accelerators, antioxidants and vulcanizing agents.

FILLERS

Fillers are inert mineral powders which are added to rubber and plastic mixtures to provide stiffness and hardness. They also serve as extenders which help decrease costs. The following are the fillers used most frequently in the wire and cable industry.

Carbon Black - The health effects of carbon black are controversial. Some authorities regard it as a non-toxic nuisance dust, however, others believe it may cause transient and permanent lung damage, heart problems, and skin irritation. It has been shown that workers manufacturing the substance experienced excess lung fibrosis, a hardening of the lung tissue.

Certain types of carbon black contain cancer causing polycyclic hydrocarbons which are adsorbed onto it during manufacture. Laboratory animal studies have demonstrated excess cancer from exposure. Human cancer studies are inconclusive. With multiple chemical exposures often the case, it is difficult to determine whether or not carbon black is the causative agent. NIOSH recommends wearing full body clothing including gloves, shoes and goggles when handling the material.

Calcium Carbonate (whiting) - Calcium carbonate itself is non-toxic, however, it is often treated with chemicals whose composition is not known.

Clay - Depending on the geological origin of the clay, it may contain crystalline silica. Crystalline silica refers to silica whose molecules are in a fixed pattern as opposed to a random arrangement defined as amorphous silica. The inhalation of silica can cause silicosis, a fibrous hardening of the lung tissue which is often debilitating and sometimes fat l.

Diatomaceous Earth - Diatomaceous earth, like clay, may also contain crystalline silica, and therefore, cause silicosis. The specific type of diatomaceous earth used by wire and cable firms should be evaluated for its crystalline silica content.

Lead Oxides - Exposure to lead is one of the more serious hazards associated with wire and cable manufacture. Lead is quite toxic. It can be ingested from contaminated hands, or if heated, inhaled as fumes. Lead is eliminated from the body slowly so even small doses over time can build to toxic levels. The main effect of lead is to interfere with the formation of red blood cells that carry oxygen to the tissues, resulting in anemia, fatigue, and gastrointestinal problems. High body concentrations can cause nerve damage.

Magnesium Oxide - Magnesium oxide is a white powder and considered to be a non-toxic nuisance dust. However, high concentrations can cause the lungs' defense mechanisms to become overloaded. The inhalation of newly generated magnesium oxide fumes upon heating can cause metal fume fever and associated blood disorders.

Metal Fume Fever is characterized by sudden onset of thirst, a metallic taste in the mouth, high fever, sweating, muscular aches, headache and general feeling of weakness. Symptoms may be delayed for 10 to 12 hours after exposure and are usually worst on days following time away from work, for example, on Monday after a nonworking weekend. Metal fume fever is not a chronic disease. All symptoms subside within 24 to 36 hours after onset. There are no specific tests to detect it and no treatment is known.

Other oxides which cause metal fume fever include zinc, copper, and in some cases, cadmium, iron, tin, manganese, nickel, selenium, and antimony.

Silica - Most of the silica used in rubber is amorphous rather than crystalline and is regarded as a non-toxic nuisance dust. However, the specific type of silica should be determined for each shop because crystalline silica can cause silicosis, a fibrous hardening of the lung tissue.

Zinc Oxide - There appear to be few hazards from zinc oxide dust inhalation. In rare cases zinc oxide has caused eczema, a cracking and scaling of the skin. If heated, zinc oxide fumes may lead to metal fume fever described above.

PIGMENTS AND COLORANTS

Azo Dyes - Many azo dyes have been found to cause cancer of the liver and bladder in animals.

Benzidine Based Pigments - Benzidine is a recognized carcinogen and has been linked to bladder cancer in humans as well as liver, bladder, and colon cancer in rats. It may enter the body as the result of inhalation, ingestion, or absorption through the skin. Benzidine based pigments may contain significant amounts of residual benzidine. They may also release benzidine when metabolized in the body. OSHA and NIOSH have recommended discontinued use of these dyes or at least reduction of exposure to the lowest possible levels where discontinued use is not practical. The use of liquids, pastes, and oil-wetted forms of the dyes are preferable to powdered forms to reduce inhalation of dusts. Good ventilation should be provided whenever these dyes are in use.

Cadmium Compounds - Cadmium compounds are recognized carcinogens and have been reported as causing an increased incidence of prostate cancer in men. In addition, they may cause irritation of lungs, coughing, chest pains, sweating, chills and weakness. Long term exposures may result in destruction of lung tissue characteristic of emphysema as well as damage to liver and kidneys.

Chromates - Certain chromium compounds, including lead chromate and zinc chromate, are regarded as cancer causing agents. They may also cause skin disorders as well as liver and kidney damage.

Lead Based Pigments - Examples of lead based pigments include yellow and orange pigments. See page 8 under Lead Oxides for further discussion of lead's hazards.

Perylene - Perylene is highly toxic and a suspected carcinogen.

Titanium Dioxide - Titanium dioxide is a mild irritant that can cause slight fibrosis (hardening) of the lung tissue without disabling injury.

Potential hazards of pigment use to workers can be reduced by the use of "color masterbatches", consisting of physical mixtures of a base rubber, oil, or wax with the required pigment. The additional cost of these masterbatches is often justified by the cleaner environment that results from their use.

Adequate ventilation, gloves, and protective clothing should be provided and good personal hygiene observed when handling pigments to avoid their inhalation or ingestion on contaminated hands or smoking materials.

ACCELERATORS

Accelerators, which are usually organic compounds, reduce the time necessary for the vulcanization or curing of natural or synthetic rubber while improving aging and other physical properties.

Diphenyl Guanidine (DPG) - Animal experiments suggest this accelerator is toxic, but effects on humans are unknown.

Ethylene Thiourea (ETU) - This commonly used accelerator for Neoprene compounds has been the subject of considerable investigation as an industrial cancer risk. Studies have shown it causes cancer and birth defects in laboratory animals. The powdered chemical is no longer distributed for rubber use, but it is still marketed as a "wetted powder" (oil-treated) and also in combination with rubber materials forming a putty-like substance. The latter form would appear to be the safer of the two, reducing both the chance of inhalation and ingestion of ETU.

Mercaptobenzothiazole (CAPTAX, MBT) - This commonly used accelerator has a very offensive odor, is a rat poison, and may also cause nausea and headaches. It is particularly irritating to the eyes and may also cause skin irritation and sensitization.

Pentaerythritol (PE-200) - This Hypalon accelerator is considered to be a nuisance dust of low toxicity.

Elemental Tellerium (TELLOY) - Elemental tellerium is an accelerator and vulcanizing agent. It is of relatively low toxicity, but may cause a garlic-like odor to the breath, drowsiness, and loss of apetite.

Tetramethyl Thiuram Disulfide (TMTD, THIRAM, THIURAD, TUEX, METHYL TUADS) - This chemical is an irritant to eyes and skin. Dermatitis in the form of eczema has occurred on hands, forearms, and feet of exposed workers. TMTD is closely related to Antabuse, a drug used to establish a conditioned reflex of a fear of alcohol in the treatment of alcoholics, and therefore, may cause an adverse reaction upon consumption of alcohol. The skin reaction portion of this reflex has been observed in rubber workers who were exposed to TMTD after drinking alcoholic beverages. Further hazards such as liver, kidney, and brain damage have been reported in experimental animals, but not confirmed in humans. In addition TMTD has been found to cause chromosomal damage in several biological systems. It may also adversely affect the activity of certain prescription drugs.

Tetramethyl Thiuram Monosulfide (MONEX, UNADS) - Like TMTD, Monex is an irritant to eyes and skin. It may cause an adverse reaction with consumption of alcohol and affect the activity of certain prescription drugs. It has also been found to cause chromosomal damage in bacteria, but not in mouse lymphoma cells.

Tetraethyl Thiuram Disulfide (ETHYL TUADS, ETHYL TUEX) - Ethyl Tuex is irritating to eyes, nose, throat and skin. Like TMTD and Monex, it may cause adverse reactions with alcohol and some prescription drugs. A National Cancer Institute study concluded that it is not carcinogenic, but that it enhances the carcinogenicity of ethylene dibromide. Therefore, the two chemicals should not be used at the same time.

Zinc Dimethyldithiocarbanate (ZIRAM, VANCIDE) - This accelerator is irritating to eyes, nose, and throat. It has also caused cancer in mice and rats.

Other accelerators which may be irritating to eyes and skin include benzothiazyl disulfide, N-tert-butyl-z-benzothiazole sulfenamide, and butyraldehyde (VAMAX).

ANTIOXIDANTS

Antioxidants are organic compounds added to rubber to slow its deterioration and retard the aging process.

Nickel Di-N-Butyldithiocarbamate (NBC) - This antioxidant is very toxic and a recognized carcinogen.

Alpha-Naphthylamine - This antioxidant is considered to be a local irritant and to cause urinary bladder cancer. It is readily absorbed into the body via the skin and through inhalation. Researchers have had difficulty determining whether alpha-naphthylamine alone or its beta impurities are responsible for the bladder cancers.

Beta-Naphthylamine (BNA) - Beta-naphthylamine is a recognized bladder carcinogen, and like alpha-naphthylamine, it is readily absorbed through the skin and by inhalation. There has been no production of beta-naphthylamine in the U.S. in the past 10 years, and it was banned in England in 1949. The use of beta-naphthylamine was widespread in both the U.S. and England in the 1940's.

Phenyl-Beta-Naphthylamine (PBNA, NEOZONE D, AGERITE POWDER) - This antioxidant was developed in the 1940's to replace beta-naphthylamine after studies linked it to bladder cancer. Commercial PBNA is not only contaminated with BNA, but in the body, PBNA is metabolized to BNA. There have been no studies linking PBNA to cancer in humans, but one mouse study showed an increased incidence of liver tumors, and another found increased incidence of all tumors. In 1973, 4.9 million pounds of PBNA were produced in the U.S. Currently there is little or no commercial production.

Workers who have been exposed to any of the naphthylamine antioxidants should have regular cytologic examinations of the urine performed in order to detect early signs of bladder cancer.

ADDITIONAL CHEMICALS USED IN THE MANUFACTURE OF RUBBER INSULATING MATERIALS

Antimony Trioxide - Antimony trioxide is used as a flame retardant and is a fairly powerful irritant of eyes, respiratory tract, and skin. It causes a type of dermatitis known as "antimony spots" characterized by intense itching followed by skin eruptions. Antimony trioxide is also a suspected carcinogen.

Organic Peroxides - These chemicals are used as crosslinking agents for some types of rubber. They can cause skin irritation and burns as well as severe eye damage. Organic peroxides tend to be unstable and fires or explosions can result from improper storage and handling. Many of these hazards can be minimized by using them in diluted form, such as 40% strength mixtures with clay.

Solvents - Solvents are used in certain auxiliary wire and cable processes, for example, coating operations, bonding of rubber insulating materials to wire and cable, special cord set operations, assembly and harness work. A wide variety of solvents are used including printing ink thinner (consisting of methyl ethyl ketone (MEK) and cyclohexanone), also xylene, toluene, and acetone which are of low toxicity.

Effects of solvent exposure include headache, dizziness, drying of the skin, and eye irritation. Areas where solvents are used should be well ventilated and the processes should be enclosed if possible. Workers should be provided with such personal protective equipment as goggles or glasses, gloves, and respirators for high exposures of short duration.

Stearic Acid - Stearic acid is an accelerator or activator used in rubber compounding. It is a white amorphous solid of slight toxicity.

Sulfur - Sulfur is a vulcanizing agent and is of low toxicity. If heated sufficiently it will emit irritating sulfur oxide fumes.

PLASTIC POLYMERS AND ADDITIVES

The most commonly used plastic polymers in the wire and cable industry are polyvinyl chloride (PVC), polyethylene, polypropylene, and nylon.

Polyvinyl Chloride (PVC) - PVC resin is used as the basis of vinyl compounds and has been the subject of considerable investigation. It is produced through the polymerization of vinyl chloride monomer (VCM), a gas. In 1974, VCM was found to cause a rare form of liver cancer known as angiosarcoma in workers exposed to high concentrations. Subsequently, it was shown to cause cancer in animals as well.

While industry has made tremendous strides in reducing the amount of residual VCM in PVC resins, some still remains. VCM may be released from PVC in storage and more rapidly when it is heated. Therefore, PVC should be stored and handled in well ventilated areas. Whenever PVC is heated sufficiently to cause mass melting, OSHA regulations require that the workplace be monitored for ambient concentrations of VCM to ensure they are in keeping with OSHA standards.

Various limits have been proposed for the residual VCM in the resin. Warning labels stating that PVC contains residual VCM, a cancer suspect agent, must be affixed to each package of PVC resin, and it is recommended that resin users request a statement of the analysis of residual VCM from each prospective resin supplier.

One of the greatest hazards associated with PVC, as with other plastic compounds, occurs when it is heated. When plastics, in general, are heated to sufficiently high temperatures, they emit potentially hazardous combustible and noncombustible gases as well as particulates. If plastics are burned, they can create a toxic atmosphere of carbon monoxide and fumes of other plastic decomposition products. These products differ depending on the type of plastic.

For most plastics, the temperature at which decomposition products are released is well above the softening temperature-the normal operating temerature for the production of plastic insulated wire and cable. This is true of polyethylene, polypropylene, and nylon. Decomposition products of these plastics include carbon monoxide, carbon dioxide, and water. The exception is PVC. Hydrogen chloride gas (HCl) begins to be released from PVC at normal operating temperatures of about 300-350°F. Appreciable amounts of HCl are released upwards of 375°F.

The major effects of acute exposure to HCl are usually limited to irritation of the upper respiratory tract and are sufficiently severe to warrant prompt withdrawal of persons from the area. Exposure to the gas immediately causes coughing, burning of the throat, and a choking sensation. Above 650°F, plasticized PVC may release other decomposition products including carbon monoxide, carbon dioxide, ethane, ethylene, benzene, toluene, and methane.

Polyethylene - The toxicity and health effects of polyethylene are unknown, although it is a suspected carcinogen. It is produced through the polymerization of ethylene monomer, a gas, which is moderately narcotic, but of low toxicity. Few, if any health problems would be expected as the result of exposure to residual ethylene monomer at concentrations present in wire and cable manufacturing plants. Exposure to heated polyethylene mixed with other plastic additives may result in irritation of eyes and respiratory tract due to two decomposition products: formaldehyde and acrolein.

Polypropylene - The toxicity of polypropylene is not known. Propylene, which is used in the manufacture of polypropylene, is a simple asphyxiant and anaesthetic. It is doubtful that residual amounts of propylene would cause a significant health threat at concentrations present in the wire and cable industry.

Nylon - The health hazards associated with nylon are unknown.

FILLERS

Calcium Carbonate Clay Carbon Black Silica	For all, see discussion under rubber fillers.

PLASTICIZERS

Plasticizers are used to make plastics soft and flexible.

Pthalates - Pthalates are the most commonly used plasticizers, and generally are of low acute toxicity. Prolonged exposure to hot mist or fumes may produce irritation to eyes, skin, and mucous membranes.

Di-2-ethylhexylphthalate (DEHP) - This compound has been found to be a liver toxicant in primates. When it is metabolized it forms an extremely toxic agent. It has been shown to have cummulative toxic effects in mice. DEHP and dimethoxyphthalate have produced chromosomal damage and caused antifertility effects in mice.

Dimethyl, Dimethoxyethyl, Diethyl, Dibutyl, Dimethobutyl, Dioctyl, Butylcarboxymethyl, and Di-2-ehthylhexyl phthalates have caused teratogenic effects (birth defects) in animals.

Tricresylphosphate (TCP) - TCP is used infrequently and can irritate mucous membranes. Careless or prolonged use can cause serious effects including certain types of paralysis. TCP is also a suspected carcinogen.

STABILIZERS

Stabilizers serve to prevent the decomposition of plastic compounds and are among the most hazardous chemicals used in plastic compounding.

Barium Compounds - Barium compounds are often combined with either lead or cadmium compounds into a stabilizer "blend". The toxicity of the barium alone is not well known. Some soluble barium compounds are irritating to eyes, nose, throat, and skin, and are toxic if ingested.

Bisphenol A (2,2 - bis (4 hydroxyphenyl propane)) - This stabilizer is of low toxicity, but can cause skin irritation and is a serious hazard to eyes. It is suggested that workers who use it wear goggles.

Cadmium Compounds - Inhalation of dust or fumes from these chemicals may cause dryness of the throat, cough, headache, shortness of breath, and vomiting. In addition, cadmium compounds are recognized carcinogens of the connective tissue, lungs, and liver. Long term exposures may destroy lung tissue, resulting in emphysema. Cadmium based stabilizers are sometimes in liquid form, minimizing inhalation.

Lead Compounds - Exposure to lead stabilizers is more hazardous than to metallic lead or lead oxide because the powders are readily inhaled and deposited on the hands. Oil-wetted forms of the stabilizers provide a reduction of inhalation, hazards and pumpable slurries, if equipment is available to handle them, should eliminate most of the exposure hazard. Health effects of lead are covered on page 8 under Lead Oxides.

Adequate ventilation, attention to personal hygiene, the use of regularly cleaned work clothing, and the prohabition of eating or smoking while working are indicated when stabilizers are used.

PIGMENTS OR COLORANTS

See discussion on Rubber Polymers and Additives

STRAINING AND MILLING

After rubber compounding, the rubber is sent to either a strainer extruder, which takes out impurities, or to a mill to be further masticated, pressed, and cooled. In both machines the rubber compound is hot allowing potentially hazardous volatile components including any residual monomer, antioxidants, process oils or waxes, accelerators, and peroxides to be released into the workplace. Therefore, local ventilation is recommended. Discussion of health hazards associated with specific chemical components of rubber insulating materials can be found in the section entitled Rubber Polymers and Additives.

RUBBER DUSTING

Dusting agents are commonly used to separate adjacent slabs of mixed rubber as well as cured or uncured rubber insulated wire and cable. Frequently used dusting agents include talc, mica, and zinc stearate.

Talc (soapstone) - Talc, or powdered hydrous magnesium silicate, is frequently used for both of the above mentioned purposes, and its use often leads to air contamination in the area, the amount depending on the method of application. In the case of slab dusting, air contamination can be lessened by replacing talc with a "slab dip" or slurry consisting of a clay or zinc stearate suspension in water. Application of talc to rubber-covered wire is ordinarily done by passing the wire through a "talc-box", which should be covered as well as possible to reduce the concentration of talc in the air.

It is well established that commercial talcs can contain substantial amounts of asbestos, which is a definite hazard to lungs, producing pulmonary fibrosis and/or cancer. Certain grades of talc, however, contain little or no asbestos. To determine the extent of the health hazard, it is important to determine the asbestos content of the talc. Talc itself may cause pulmonary fibrosis.

Mica - Mica is occassionally used for dusting rubber insulations, and while it is a nonfibrous silicate, it can cause chronic fibrosis, a restrictive lung disease characterized by chronic coughing, weakness and weight loss.

Zinc Stearate - This white powder is sometimes used as a dusting agent for purposes that require its melting and absorption by the rubber. The inhalation of zinc stearate can cause pulmonary fibrosis.

Adequate ventilation should be provided when these dusting agents are in use.

RUBBER AND PLASTIC EXTRUSION

After the rubber and plastic compounds have been made into suitable insulating materials, they must be applied to the wire. This is done primarily through the use of some type of extruder. Insulation is applied either as a "single shot" integral insulation and jacket, or as an insulation to be later combined with other "singles" into a multiconductor group and covered with an overall jacket.

RUBBER EXTRUSION

As the rubber is being extruded onto the wire, it is cured in a continuous vulcanizing (CV) tube filled with high pressure steam. Little opportunity exists for inhalation of toxic chemicals in this process since it is all enclosed.

An alternate method of extrusion for some cables involves feeding both the cable and the rubber compound into a lead press which then applies a lead sheath over the jacket of the cable. The lead press holds the rubber in a round shape and cures it. In some cases the sheath is left on, while in others it is removed with a stripping machine, melted and reused later. The stripping process releases small particles of lead into the workplace. These particles can be inhaled or ingested from contaminated hands. Because the lead is heated in order to melt it, exposure to lead fumes is another potential hazard. See discussion of lead hazards on page 8 under Lead Oxides.

PLASTIC EXTRUSION

Plastic compounds must be heated in the extruder before they can be formed around the wire. In nonautomated systems, the head of the extruder sits at working level about 4 feet from the floor and is uncovered so that it may be attended by the operator. As a result, operators may be exposed to plastic fumes. In automated systems, plastic compounds in the form of pellets are pumped directly into the extruder reducing exposures to plastic chemicals. Even with automated systems, fumes may escape into the workplace at the point where the newly insulated wire exits the extruder.

Plastic fumes from compounds heated to normal extrusion temperatures of about 300-350°F consist primarily of the plasticizer portion of the compound. Trace amounts of monomer may be present and could be given off during extrusion, but it would be expected that the mixing operation would have removed the major portion of such volatiles. The metallic salts present as stabilizers should be fully incorporated into the compound and of no further concern at this point. The organic portions of these stabilizers may, however, be released.

Hydrogen chloride (HCl) gas can be evolved from vinyl compounds during extrusion, although it is expected that only small amounts of HCl would be given off at normal operating temperatures.

There can also be exposure to purging compounds, usually ground plastic materials, or styrene, which are used to clean extruder screws of charred vinyl compounds. If heated too high, these compounds can release potentially toxic and irritating fumes.

The process of bleeding the machine of a plastic compound of one color to replace it with one of another color also results in the release of potentially toxic substances.

Therefore, for the above mentioned reasons, it is recommended that plastic extruders be equipped with local exhaust ventilation.

SPARK TESTING

Rubber insulated wire is passed through a high voltage electrode in order to locate faults in the insulation in a process called spark testing. Ozone gas can be generated by the electrode, the amount depending on the voltage used. Under 10 KV would not produce much ozone, but higher voltages produce greater amounts. It is not likely that much ozone would be produced during normal fault finding procedures since the electrode does not spark continously and ozone is self destructing. Any ozone that would be generated would disappear fairly quickly.

However, when wire is tested in the laboratory to determine the adequacy of the insulation, significant amounts of ozone may be released if high voltage dielectric testing devices are left on for long periods of time. Operators of the devices should not be in the area if significant amounts of ozone are generated, and they should not return until the ozone has been exhausted.

Ozone - The effects of ozone range from throat irritation at low concentrations to severe pulmonary edema (excess fluid in the lungs) at high concentrations. Very high concentrations of ozone may cause bronchitis characterized by persistent cough and excessive mucous production. In addition, animal experiments have shown that ozone at levels less than industrial health standards significantly affect the animals' antibacterial defenses.

BRAZING

The purpose of brazing is to join short lengths of wire through the use of some type of heated flux or solder. The procedure takes about 1½ to 2 minutes for each braze and is done approximately 10 to 20 times per day. Depending on the type of flux or solder used, brazing may result in the release of potentially toxic fumes.

One commonly used brazing material is silver solder which contains silver, zinc, and sometimes copper, brass, fluorides and cadmium. Silver is irritating to skin and mucous membranes and causes the skin to turn grey. However, it is not know to cause disability. When heated, fumes of zinc, brass, and copper may cause metal fume fever described on page 8. These metals, as well as fluoride and cadmium, may be irritating to skin, eyes, and respiratory tract. Cadmium is a recognized carcinogen and long term exposure may result in destruction of lung tissue as well as liver and kidney damage. Fluorides have the potential for causing permanent lung damage.

Local ventilation at the workbench is recommended to exhaust brazing fumes. Personal protective equipment should include safety goggles or shield, and gloves to protect workers from sparks or spatterings of brazing materials.

MEDICAL MONITORING OF WORKER HEALTH

While many workers who are exposed to potentially hazardous substances will not develop a health-related problem, it is very important for exposed workers to seek medical attention. Medical monitoring of worker health, can often detect problems early enough to prevent them from becoming debilitating or life threatening. Since each worker is exposed to different agents depending on the type of job he/she does, there is no one set of medical tests which is suitable for everyone. Because different exposures can result in different health effects, each worker should see his or her physician for an individualized medical examination.

There are, however, specific tests which can be performed to detect problems arising from particular exposures.

1) Anyone exposed to noise levels in excess of OSHA standards, for example wire drawers should be given pre-employment audiometry (hearing tests) to detect pre-employment levels of hearing impairment followed by annual audiometric tests to determine subsequent levels of impairment.

2) Pre-employment medical evaluations are advisable for workers who will be exposed to pulmonary irritants or agents causing pulmonary fibrosis such as asbestos, talc, mica, zinc stearate, silica (for example in clay or diatomaceous earth), and carbon black. The purpose of these evaluations is to determine the existence of pre-employment pulmonary disease and to provide baseline data for future medical test comparisons.

A chest X-ray after one year of employment is recommended to detect workers having early reactions to pulmonary irritants and fibrotic agents. The frequency of subsequent chest X-rays is controversial with recommendations ranging from 3 to 5 years. In addition to periodic chest X-rays, annual Pulmonary Function Tests (PFT's) should be performed on workers exposed to these substances.

3) Workers exposed to potential carcinogens should have thorough annual medical evaluations. These evaluations should include a complete blood count, a stool examination for the detection of occult blood, and a urinalysis.

In particular, workers exposed to the following substances should have specific tests performed.

a) Asbestos - Chest X-Ray, Pulmonary Function Tests, Sputum Cytology. Special attention should be paid to the pulmonary, gastrointestinal, and cardiovascular systems.

b) Benzidine, Azo Dyes, Naphthylamines - Annual Cytoscopy of the Urine. Special attention should be paid to people who are taking steroid preparations, cytologic drugs, or who smoke or are pregnant since they have an increased risk of contracting bladder cancer.

c) Cadmium - Pulmonary Function Tests, Chest X-Ray, Urinalysis with a quantitative analysis of protein in the urine. Special attention should be paid to the pulmonary and urinary systems.

d) Chromates - Chest X-Ray, Pulmonary Function Tests, Urinalysis. Special attention should be paid to the skin as well as the pulmonary and urinary systems.

e) Nickel Compounds - Chest X-Ray. Special attention should be paid to the examination of the nasal cavities, skin and pulmonary system.

4) Workers who are exposed to lead should receive annual physical examinations with special attention paid to the central nervous system as well as the gastro-intestinal, urinary, and circulatory systems. Annual tests such as a complete blood count, urinalysis, and blood lead - Free Erythrocyte Protoporphyrin Test-should be performed.

For more information about medical surveillance procedures, individual workers, unions, and management are encouraged to call one of the following occupational health medical testing facilities in the greater Providence area.

1) Rhode Island Hospital's Industrial and Environmental Medicine Clinic
Providence, Rhode Island
Andrew Rosner - Clinic Coordinator
(401) 277-5723

2) Program of Occupational Medicine
Brown University
Michael Passero, M.D. - Director
(401) 456-2060

3) Occupational Health Service, Sturdy Memorial Hospital
Attleboro, Massachusetts
Robert McCunney, M.D. - Medical Director
(617) 222-5200 Ext. 3294 or 3295

4) The Rhode Island Poison Center, Rhode Island Hospital
Providence, Rhode Island
(401) 277-5727

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