Wire, Cable & Cadmium

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Cadmium-containing materials are used in many segments of the wire and cable industry and work is ongoing to find alternatives to this hazardous substance. Such work in the area of copper alloys has already resulted in a family of cadmium-free copper alloy conductors.

Cadmium in Wire & Cable

Cadmium has had a wide variety of uses in the wire and cable industry as pigments for insulation, stabilizers for PVC, plating of electrical connector shells and in alloy conductors.

Insulation coatings containing cadmium colorants can be found on wire and cable products. In addition to color, the cadmium also contributes to the pigment's durability against fading and resistance to heat. Cadmium compounds are used as stabilizers for polyvinyl-chloride (PVC) plastics to retard degradation due to ultraviolet light and heat. PVC is still a popular wire and cable insulation system today.

Cadmium as a coating has a good combination of corrosion resistance, lubricity, electrical conductivity and solderability. Aluminum connector shells plated with cadmium are used in many cabling applications.

Cadmium copper, alloy C162, is predominantly used as a high-strength electrical conductor. Applications that require high electrical conductivity and higher strength than pure copper are well suited for this alloy. Overhead trolley wire used for electric locomotives and buses use cadmium copper for its wear resistance. European aircraft manufacturers use cadmium copper for applications for which pure copper is insufficient in strength.

Copper alloy C18135, also known as PD135, is a high-strength alloy conductor that has cadmium and chromium as alloying elements. The alloy has similar tensile strength and conductivity to cadmium copper with the additional property of increased stability to thermal softening. This alloy is used when engineering requirements call for a high-performance wire and cable. The USA's military and commercial aircraft manufacturers, amongst others, use C18135 alloy for many wire and cable applications.

Cadmium is Hazardous

Cadmium is a hazardous material and the pollution concerns surrounding this metal have been widely published over the years. The **Environmental Protection Agency's (EPA's)** list of persistent, bio-accumulative and toxic (PBT) chemicals was compiled to identify chemicals and chemical categories that may be found in hazardous wastes regulated under the Resource Conservation and Recovery Act (RCRA). This list was created to help implement the EPA's national RCRA waste minimization policy and it is used to promote voluntary waste minimization efforts to reduce the generation of PBT chemicals. Cadmium appears on this list with groundwater and airborne contamination as major concerns.

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Cadmium occurs naturally in zinc, lead and copper ores, which can be a source of its release when in contact with acidic ground or surface water. Large industrial releases have been mainly attributed to waste streams and leaching of landfills from operations involving cadmium or zinc. The release of cadmium can occur during many stages of a product's life. The manufacture of raw materials involving cadmium such as mixing of pigments, plating or casting of alloys involves cadmium in a soluble or particulate form. Wastes and bi-products from these manufacturing operations introduce cadmium into the environment. Disposal of cadmium-containing products in landfills, incineration, remelting of alloys or improper recycling in general will also release cadmium to the environment.

When cadmium enters the food chain and is ingested, it causes damage as it accumulates in the liver and kidneys. High concentrations of cadmium in kidneys can lead to proteinuria (protein in the urine) and excretion of calcium from bones. The short-term effect of inhalation of high levels of cadmium fines or vapors in humans is mainly to the lungs, appearing as pulmonary and bronchial irritation. A single exposure to high levels of cadmium can result in long-lasting impairment of lung function. Long term inhalation of low levels of cadmium can possibly lead to emphysema. Studies on animals have shown damaging effects on the kidneys, liver, lungs, bone, immune system, blood and nervous system from long term exposure to cadmium.

It is to be noted that cadmium affects the body at levels lower than those established for lead. The EPA considers cadmium to be a probable human carcinogen and has classified it as a Group B1 carcinogen. It therefore falls under the Waste Minimization National Plan.

Cadmium Restrictions

Cadmium restrictions differ in various parts of the world and more severe restrictions are passed each year. As previously mentioned, in the USA cadmium appears on the EPA hazardous materials list. Cadmium's use is not prohibited, but minimization of its use and control of its release to the environment has been a priority. California is one state in the USA that has initiated legislation to eliminate hazardous materials such as cadmium from entering its borders. *Proposition 65* effectively bans sales of specific products containing hazardous materials such as cadmium in the state and also keeps shipments of similar items from entering California.

A January 1, 2007 deadline has been proposed by the **European Commission** to reduce Waste from Electrical and Electronic Equipment (WEEE) as part of the *Restriction of Hazardous Substances (RoHS)* directive. Hazardous materials such as cadmium, lead and mercury (among others) will be restricted from a wide variety of equipment. Small household appliances such as televisions, audio equipment, toys and tools are included in the directive. A decision on this proposal is ex-

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pected in mid 2002 with the possibility of a deadline sooner than January 2007. The requirement of the directive is:

> *...the substitution of mercury, lead, hexavalent chromium, cadmium and polybrominated biphenyls (PBB) and polybrominated diphenyl ethers (PBDE) brominated flame retardants in electrical and electronic equipment.*

Proposed legislation is also pending to require electrical and electronic equipment manufacturers to be responsible for their products throughout their service lives including their disposal. This "Take-Back" policy will require manufacturers to bear the costs of proper recycling and disposal. *Directive 94/62/EC*, which is already in force, limits the amount of cadmium contained in packaging materials to be less than 0.01% (100 ppm).

Japan has instituted laws regulating hazardous waste emissions for the last 30 years. The *Waste Disposal Law*, the *Water Pollution Control Law* and the *Agricultural Land Soil Pollution Prevention Law* were all enacted in 1970. These and other pollution laws fall under the umbrella of the *Basic Environment Law* enacted in 1993. It is noteworthy that cadmium was included as a hazardous substance since the initial enactment of these laws.

"Developments in copper alloys for wire and cable have created new cadmium-free alloy conductors. Copper-based Percon® alloys are cadmium free and have fully equivalent mechanical, physical as well as long-term performance properties."

USA automobile manufacturers have effectively banned the use of cadmium-containing materials in all their products. In November 2001, the Netherlands blocked the sale of a popular home video game, citing that some of the control cables had wire containing excessive levels of cadmium. The authorities claimed that the wire contained between three to 20 times the maximum 0.01% acceptable level of cadmium in consumer electronics. The manufacturer responded by replacing the cables in all the units.

Standard *MIL-STD-961D* of the USA's **Department of Defense (DOD)** establishes guidelines for hazardous substances as well as recycled, recoverable and environmentally preferable materials for use in military specifications.

Cadmium Alternatives

As environmental concerns and restrictions mount regarding hazardous materials such as cadmium, attention has been focused on developing alternatives. The goal is to provide equivalent or increased performance with advantages over toxicity and environmental impact.

The pigment industry has responded by developing new colorants based on organic materials and other elements. The newly developed colorants span a variety of shades that can effectively replace many of the cadmium-based colors, however some of the hues and intensities of the original colors have not been achieved as yet.

Stabilizers for PVC have also been developed based on different materials such as zinc and calcium that have been effective to the effects of light and heat.

Alternatives to cadmium plating have also progressed. Research into replacing cadmium plating with Ion Vapor Deposition (IVD) and nickel-boron plating on aluminum electrical connector shells has been performed by the **Air Force** in the USA. Unplated metal connector systems such as stainless steel, titanium and nickel-bronze were also investigated. Sophisticated plastics and other organic connector materials are also under development and many automotive applications have already been converted. However, switching military applications from cadmium platings to organic alternatives will require more performance testing.

New Cadmium-Free Copper Alloy Conductors

Developments in copper alloys for wire and cable have created new cadmium-free alloy conductors. Specifically, cadmium copper, C162, can be replaced directly using Percon® 17. Products using alloy PD135 can utilize Percon® 24 as a drop-in replacement. Both of these copper-based Percon alloys are free of cadmium and they offer fully equivalent mechanical, physical and long-term performance properties. Test results have been evaluated by the **Naval Air Systems Command (Navair)**, which has concluded that Percon 24 may be utilized for qualifying military wire requiring a high-strength copper alloy conductor.

Conclusion

Cadmium is a hazardous material and its use must be reduced or eliminated wherever possible. Developing alternatives for products containing cadmium is a necessary responsibility of the wire and cable industry. The makers of copper alloys have already developed cadmium-free alternative alloys. Percon 17 and Percon 24 are cadmium-free alloys engineered specifically for wire and cable applications.

As research into alternative materials for other products proceeds, many new cadmium-free substitutes that are direct drop-in replacements, such as Percon alloy conductors, will be developed. The wire and cable manufacturing industry needs to be proactive in adopting these environmentally preferred materials.

To learn more about cadmium-free Percon alloy conductors, contact the author. **WCTI**

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US Environmental Protection Agency (EPA) *www.epa.gov*

Company Profile...Fisk Alloy Conductors, Inc. *employs technologies for fine wire drawing, stranding, and heat treating copper alloys and bimetallic composites to produce specialty stranded conductors. These alloy conductors are used in applications where operating temperatures, strengths, flexibility or ambient environment causes copper wire failure. Fisk Alloy Conductors, Inc., is part of* ***Fisk Alloy Wire, Inc.****, which makes copper alloy wire to meet specific alloy, shape and product quality requirements.*