*Project S.E.N.S.O.R. News

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Respiratory Hazards in the Automotive Industry

Despite layoffs and down sizing the production of automobiles and trucks is Michigan's major manufacturing industry. Approximately seventy-five percent of autoworkers produce vehicle parts and 25% assemble the final vehicles. This distribution between vehicle assembly and parts manufacturing is important from the health care provider's perspective. Vehicle parts manufacturing has significantly more respiratory hazards since it involves processes such as casting metal parts in foundries, machining metal parts, manufacturing foam products, and extruding and injecting plastic into molds. In contrast, vehicle assembly requires a great deal of material handling as the various parts are assembled into the final vehicle. Accordingly the major health concern in vehicle assembly facilities involves musculoskeletal conditions. However, important activities in vehicle assembly that generate potential respiratory hazards are welding, painting and the use of adhesives (Table 1).

VEHICLE PARTS MANUFACTURING

FOUNDRIES

Foundries produce metal parts by pouring molten metal into molds. In order to create internal cavities in the metal pieces being produced, cores made from sand are used. After the metal hardens the mold and core must be removed and the metal smoothed. The activity of removing

Table 1. Work Processes, Exposures and Respiratory Conditions in the Automotive Manufacturing Industry

	Work Process	Exposure	Respiratory Condition
Vehicle Parts Manufacturing			
Metals	Casting	Silica, Asbestos, Benzopyrene	Asbestosis, COPD, Lung Cancer, Silicosis
	Chipping/Grinding	Silica	COPD, Lung Cancer, Silicosis
	Core/Mold Production	Silica, Isocyanates	Asthma, COPD, Lung Cancer, Silicosis
	Machining	Metal Working Fluids	Asthma, Hypersensitivity Pneumonitis
	Forging/Stamping	Drawing Compounds	Asthma, Hypersensitivity Pneumonitis
Polyurethane Foam	Foam Production for Seats, Arm Rests	Isocyanates	Asthma
Plastic Parts	Extrusion/Injection Molding	Styrene, Polyvinyl Chloride, Polyethylene	Asthma, Bronchitis
Carpeting/Liners	Flocking	Nylon Flock	Interstitial Fibrosis
Vehicle Assembly			
Body Shop	Welding	Welding Fumes, Nitrous oxides, Ozone, Particulates	Asthma, COPD
Paint Line	Painting	Isocyanates	Asthma
Assembly	Gluing	Isocyanates, Epoxies	Asthma

the mold and core is conducted in the "finishing" or "clean" room. Activities there include knocking off the sprue (hardened metal from where the pour goes into the mold), shake out and chipping and grinding. During pouring, the molten metal heats the silica. Because heated silica is transformed into more fibrogenic forms, tridymite and cristobalite, and the removal of sand generates a large dispersion of particulates, the "cleaning" area of a foundry is the location with the highest risk for silica exposure. Silica exposure is also significant in the mold and core areas and among any workers responsible for handling and cleaning up spilt sand. Asbestos exposure has occurred among workers maintaining furnaces, pipes and cupolas (the latter being the containers in which molten metal from furnaces are transferred to the molds). Removal of fire brick in furnaces and cupolas has been a high risk job for both asbestos and silica exposure.

A common method for making sand molds and cores involves the mixture of TEA gas (tetraethylamine) and an isocyanate such as methylene diisocyanate (MDI). Ruptured or disconnected hoses are not uncommon causing acute exposure. TEA gas is associated with difficulty in vision, particularly night vision. MDI is a common cause of sensitization and work-related asthma. An alternative method is a hot process involving a phenolic-formaldehyde resin. Formaldehyde exposure from this process is a cause of work-related asthma.

Alternative foundry processes, such as lost wax casting, or lost foam casting, that do not use silica or use less silica and do not use known sensitizers have become more common in recent years.

Lung cancer is increased among current and former foundry workers making vehicle parts. Historically, there has been exposure to three carcinogens in the foundry environment; asbestos, benzopyrene from the fumes of the molten metal and silica.

METAL MACHINING

Metal pieces need to be cut, drilled, shaped and smoothed. In order to facilitate this machining, metal working fluids (MWFs) are used. These substances are commonly called "coolants." There are four types of metal working fluids, straight (natural, mineral oil), emulsified, semi synthetic and synthetic fluids. Straight fluid as the name implies is 100% mineral oil. Water based oils are now more commonly used; emulsified oil is an emulsion of mineral oil and water, semi synthetic, which contains smaller amounts of mineral oil than the emulsified oils, and synthetic oils which contain no mineral oils. Individual components of the water based metal working fluids such as ethanolamine compounds, have been shown to cause work-related asthma, documented by specific antigen bronchoprovocation testing.

Hypersensitivity pneumonitis (HP) from exposure to MWF was first reported in the mid 1990's in a facility in Michigan that manufactured vehicle parts. A dozen or more outbreaks have subsequently been reported in the literature. Mycobacteria immunogenum has been the most common suspected etiologic microbiologic agent. Patients are usually nonsmokers, have symptoms of cough, dyspnea and fever, have ground glass opacification on their HRCT and have restrictive changes on pulmonary function testing and decreased diffusing capacity. Respiratory symptoms and radiograph changes will clear and pulmonary function changes will markedly improve over a period of months if the patient is removed from exposure soon after the onset of symptoms. If the patient is not removed from exposure then fibrosis and increased respiratory symptoms are increasingly likely as exposure continues and less likely to clear after removal from exposure. The sporadic nature of these outbreaks has remained perplexing. Are there truly outbreaks associated with over growth of certain microbiological species or are there endemic, ongoing cases that are misdiagnosed as atypical pneumonia.

Work-related asthma has been identified in the same facilities where outbreaks of HP have been recognized. In a recent report of an outbreak of HP in an automotive engine manufacturing facility, work-related asthma was more common than HP. In the state of Michigan, MWFs are the second most common cause of work-related asthma.

FORGING/STAMPING

Similar to machining, metal working fluids, called drawing compounds, are used when cold rolled steel is stamped out into metal parts (stamping) or compressive force is used on heated metal to form metal parts to conform to the shape of dies (forging). The potential for the development of asthma and hypersensitivity pneumonitis in forging and stamping would be similar to machining.

CARPETING/LINERS

In one process to make vehicle carpeting, and interior lining, short nylon, rayon or polyester fibers (flock) are glued to a cotton-polyester fabric substrate. In the early 1990's outbreaks of interstitial disease were first noted in facilities making nylon flock. No temporal association was noted in the short term with work (i.e. improvement on the weekend) but with prolonged removal from work of weeks to months some individuals improved but then had reoccurrence on return to work. Half of the reported cases had decreased total lung capacity and/or forced vital capacity and decreased diffusing capacity. Although several of the cases had normal chest radiographs, their HRCT showed ground glass opacities with a peripheral predominance. A distinctive histology was described that showed "lymphocytic bronchiolitis and peribronchiolitis with lymphoid hyperplasia represented by lymphoid aggregates". Transbronchial biopsies in contrast or lavage did not profile sufficient tissue in relation to the pulmonary lobular architecture for diagnosis.

POLYURETHANE FOAM

Isocyanates are commonly used in vehicle parts manufacture to make seat cushions, inner padding such arm rests, and bumpers and fascias.

Across all types of industry, isocyanates are the most common etiologic agents of work-related asthma. MDI and polymeric forms of the isocyanates are used more frequently than toluene diisocyanate (TDI). Generally day to day exposure measured by the 8-hour time weighted average of exposure is below the regulatory standard, which is in the thousandth of a part per million. However, spills and leaks and clean up of these spills without proper protective equipment are times of increased exposure. Studies on the potential for skin exposure even after mixture of the amine catalyst and the isocyanate during the time the material is "curing." In animal models skin exposure alone can cause sensitization and asthma (PS News, Vol. 16 No. 2).

PLASTIC

The two common manufacturing processes for plastic parts are injection molding and extrusion. In injection molding, plastic granules or powders are heated to fluid and then forced into a metal mold where it hardens and assumes the shape of the product. In extrusion, heating softens the plastic and then the softened plastic is forced through a die and on cooling assumes the shape of the die.

Since heat is involved in both processes, plastic fumes may be released into the air. A machine may be dedicated to a particular plastic, more often the same machine is used for multiple different types of plastic and the machine needs to be "purged" when the plastic is switched. The highest exposures occur during purging. During purging the machine is superheated and residual plastic in the machine is burnt off. With multiple machines in the same area a worker may be exposed to fumes from purging even though the machine they are operating is not being purged.

Identification of the plastic used in the machine when the patient has respiratory problems is important in evaluating the cause of the patient's respiratory problem. Some plastics contain ingredients that have caused sensitization and work-related asthma. These include styrene and formaldehyde, and a single case report with a positive specific antigen bronchoprovocation test for polypropylene.

A self limited condition associated with manufacturing plastic parts is "polymer fume fever" after exposure to polytetrafluoroethelyene. Here an individual will develop flu like symptoms in the evening after work with fever, headache, chills, and myalgia that typically resolves in 24 – 48 hours. Symptoms typically occur on return to work when the individual has not been exposed for a period of time (i.e. after a vacation, and will not reoccur the rest of the week). The condition is similar to metal fume fever from exposure to zinc oxide fumes given off when galvanized (zinc coated) metal is burnt, or cut.

VEHICLE ASSEMBLY

BODY SHOP

In a typical car over a thousand welds are necessary to assemble the vehicle. This work is performed in the "body shop" where in a modern facility hundreds of robots will be performing welding. The area is typically noisy from the manipulation of so many metal parts and the movement of these metal parts along the line. Workers are required to wear hearing protection and special gloves to reduce cuts from handling the sharp metal pieces. Even though the workers in an automated body shop are not doing the actual welding, they are in close proximity to where the welding is performed and are potentially exposed to welding fumes.

Ozone and nitrogen oxide and particulates are produced during the welding. Studies of workers in vehicular "body shops" have reported increased respiratory symptoms.

PAINT LINE

Vehicular paint usually contains the isocyanate, hexamethylene diisocyanate (HDI), a well-recognized cause of work-related asthma. Vehicular painting is performed in assembly facilities typically with separate ventilation and exhaust systems from the rest of the assembly operations. The paint area has a limited number of workers who wear respirators and skin protection thus markedly reducing the likelihood of exposure. Access is limited to the paint areas not only because of health concerns but because of the concern about the off gassing of perfumes, colognes and shampoo that are worn by individuals which effect the bonding of the paint to the vehicles. The potential for adverse health effects is greatest during spills, leaks and maintenance as compared to routine operations. The levels of protective equipment provided and work practices during spills or leaks and maintenance activity are important factors affecting exposure.

ASSEMBLY

During assembly some of the adhesives used may contain chemicals that cause asthma; isocyanates and/or epoxies. For example, an isocyanate adhesive is used to attached the front and rear windows in a car. Exposure, however, is limited as the adhesive has a low volatility and is applied by a robot which limits the potential for skin exposure during routine work. Inadequate protection during clean up of spills or leaks or during maintenance will determine if there is exposure potential for developing asthma.

We remain interested in receiving reports of your patients with work-related respiratory disease. Dr. Rosenman can provide consultation on diagnosis and management. He can be reached at 1-800-446-7805.

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*PS *Remember to report all cases of occupational disease!*

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Michigan Law Requires the Reporting of Known or Suspected Occupational Diseases

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