# Evaluation of Work-related Health Concerns at a Tire Manufacturing Plant

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## Contents



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The cover photo is a close-up image of sorbent tubes, which are used by the HHE Program to measure airborne exposures. This photo is an artistic representation that may not be related to this Health Hazard Evaluation.

# Highlights of this Evaluation

The Health Hazard Evaluation Program received a confidential request from three employees at a tire manufacturing plant. The employees were concerned about chemical exposures and their health effects.

## What We Did

- We visited the tire manufacturing plant in December 2012.
- We interviewed employees about health concerns and health-related and safety-related communication in the workplace.
- We reviewed the company's exposure measurement database.
- We toured the plant and observed work practices.
- We looked at the exhaust ventilation systems.

## What We Found

- Employees reported low levels of work-related health concerns.
- Some employees reported concerns about not knowing what chemicals they were exposed to. They also reported concerns about possible future health problems from exposure to chemicals.
- The company's database for exposure measurement tracked exposures to chemicals and monitored the effectiveness of controls.
- The general and local exhaust ventilation systems were operating properly.

We evaluated occupational health concerns at a tire manufacturing plant. We found that the ventilation systems were operating properly. None of the personal breathing zone air samples the company collected during the past 5 years exceeded occupational exposure limits. We recommend that the company explain exposure measurement results to employees in plain language. An occupational health physician should assess work-related health problems.

## What the Employer Can Do

- Explain exposure measurement results to employees.
- Designate a point of contact for addressing questions or concerns about material safety data sheets.
- Explain to employees how the ventilation system works.
- Prepare regular summary reports of employees' health and safety concerns and how they are addressed to share with all employees.
- Refer employees who report possible work-related respiratory conditions to an occupational medicine physician.

## What Employees Can Do

- Report concerns about exposures and ventilation to your shift safety coordinator.
- Learn about cancer risks, measures to reduce risk for preventable cancers, and availability of cancer screening programs.
- Report respiratory symptoms or other symptoms you think might be related to work to your supervisor so they can be properly followed up.

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## Abbreviations

| | |
|---|---|
| ACGIH® | American Conference of Governmental Industrial Hygienists |
| NIOSH | National Institute for Occupational Safety and Health |
| OEL | Occupational exposure limit |
| OSHA | Occupational Safety and Health Administration |

# Introduction

The Health Hazard Evaluation Program received a request from three employees at a tire manufacturing plant in South Carolina. The employees were concerned about exposure to chemicals used in tire manufacturing and potential work-related health outcomes such as cancer, respiratory problems, and skin burns. The requestors reported that the ventilation system was turned off at night and on weekends.

We evaluated the plant in December 2012. We held an opening meeting with corporate and local managers, crew leaders, safety coordinators, corporate industrial hygienists, the plant nurse, and other employees to discuss the request. Following this meeting, we toured the plant and observed workplace conditions and work processes and practices. We interviewed randomly selected employees about work-related health concerns, communication between managers and employees, and perceptions of the physical working environment. We observed the plant's exhaust ventilation systems and reviewed the corporate industrial hygiene exposure measurement database. In December 2012, we sent a letter containing our preliminary findings and recommendations to the plant's safety and health service leader, the primary employee requestor, and a former employee who asked for a copy of documentation related to the health hazard evaluation.

## Plant Description

The 1.8 million square foot tire manufacturing plant had been operating since August 1998 and produced about 24,000 tires daily. At any given time 29 crews operated in the plant. At the time of our evaluation the union-free workforce consisted of 718 machine technicians (production employees), 77 service technicians (maintenance employees), and 132 salaried team members. The plant ran two 12-hour production shifts each day; the day shift was from 6:45 a.m. to 7:15 p.m., and the night shift was from 6:45 p.m. to 7:15 a.m. The shifts overlapped by 30 minutes to ensure a smooth transition. Each department had a safety coordinator.

## Production Process

The production process began with the selection of natural and synthetic rubber along with special oils, carbon black, pigments, antioxidants, silica, and other additives that combine to provide the exact characteristics wanted. Separate compounds were used for different parts of the tire. A Banbury® mixer combined the raw materials for each compound into a homogenized batch of black material with a gum-like consistency. The mixing process was computer-controlled to ensure uniformity. The compounded materials were then sent to machines for further processing into the sidewalls, treads, or other parts of the tire.

The first component to go on the tire building machine was the inner liner, a special rubber that was resistant to air and moisture penetration and took the place of an inner tube. Next came the body plies and belts, which were often made from polyester and steel. Plies and belts gave the tire strength while also providing flexibility. The belts were cut to the precise angle and size the tire engineer specified to provide the desired ride and handling characteristics. Bronze-coated strands of steel wire, fashioned into two hoops, were implanted into the sidewall of the tires to form the bead, which ensured an airtight fit with the rim of the wheel. The tread and sidewalls were put into position over the belt and body plies, and then all the parts were pressed firmly together. The end result was called a "green" or uncured tire.

The last step was curing the tire. The green tire was placed inside a mold and inflated to press it against the mold, forming the tread and the tire identification information on the sidewall. In a process called vulcanization, the green tire was heated to more than 300 degrees Fahrenheit for 12 to 15 minutes to bond the components and to cure the rubber. Every cured tire was then visually inspected. In addition, tires may have randomly received more intense inspection that could include x-rays, disassembling (to look for flaws), and road testing (to evaluate handling, mileage, and traction performance).

# Methods

## Confidential Medical Interviews

We interviewed two of the three employee requestors by telephone prior to the site visit. We were unable to reach the third requestor. They reported that two employees had been diagnosed with cancer; one with colon cancer and one with an unknown type of cancer. We did not pursue the cancer cases further, but chose instead to focus our investigation on exposures and respiratory issues.

Machine technicians were randomly selected for confidential medical interviews using a company roster and a random number generator. The interviews focused on medical history, work-related health concerns, personal protective equipment use, knowledge of the company's intranet, communication between employer and employees, trust in the employer, and perceptions of the ventilation and air circulation in the plant. We also interviewed two former employees who contacted us by telephone.

Employees who reported seeing a physician for work-related health concerns were asked to complete medical record release forms. We reviewed the records to determine if the symptoms or diagnoses could be linked to workplace exposures.

We also interviewed the plant nurse regarding employee health records, workers' compensation claims, and Occupational Safety and Health Administration's (OSHA) Form 300 Logs for Work-Related Injuries and Illnesses. We asked the company to provide us with the medical records for employees who had filed workers' compensation claims for respiratory illness and reviewed these as well.

## Ventilation Assessment and Review of the Plant's Industrial Hygiene Database

We were briefed by corporate and local managers on the operation of the plant, including chemicals handled, work practices, ventilation systems, the electronic material safety data sheet database, and were given a demonstration of the corporate industrial hygiene measurement database. We reviewed the last 5 years of industrial hygiene measurement results, and noted how the database was used to track trends. We also discussed how the database was used to determine when additional sampling was necessary. We toured and observed the entire plant and confirmed the proper operation of the general and local exhaust ventilation systems in each department.

# Results and Discussion

## Confidential Medical Interviews

We interviewed 79 employees individually in private. None of the randomly selected employees declined to participate in an interview. Of the interviewed employees, 84% were male, and the average age was 42 years (range: 22 to 57). These employees reported an average of 9 years (range: < 1 to 15 years) of employment with the company. Of those interviewed, 51% worked on the day shift.

Employees were asked to report the types of personal protective equipment they regularly wore on the job. Table 1 includes the number and percentage of employees reporting personal protective equipment use. Nearly all employees (96%) reported daily use of safety glasses, hearing protection, and safety shoes, all of which were required in the plant.

Table 1. Employees' reported daily personal protective equipment use at work (N = 79)

| Type | Employees reporting regular use (%) |
|---|---|
| Safety glasses, hearing protection, and safety shoes | 76 (96) |
| Gloves | 57 (72) |
| Respirator | 6 (8) |
| Sleeves | 5 (6) |
| Hard hat | 4 (5) |
| Face shield | 4 (5) |
| Headsock | 3 (4) |

### Work-related Health Concerns

Employees were asked a series of questions about their medical history to determine whether any health problems could be associated with work-related exposures. We also asked "Have you had any health problems that you think may be related to your work?" Thirteen of 79 (16%) employees believed they had work-related health problems. These employees may have listed more than one symptom, the most common being headache (4) and musculoskeletal aches/pains (4). Three or fewer employees listed sinus problems, nosebleeds, hyperthyroidism, upper respiratory infection, insomnia, skin rash, and burning eyes.

Participants were asked to rate their level of concern with "work-related health" on a scale from 0 (not at all concerned) to 10 (very much concerned). The average work-related health concern score was 3.9 (N = 79). Figure 1 shows the distribution of work-related health concern scores. Most (76%) participants rated their work-related health concern as 5 or less.

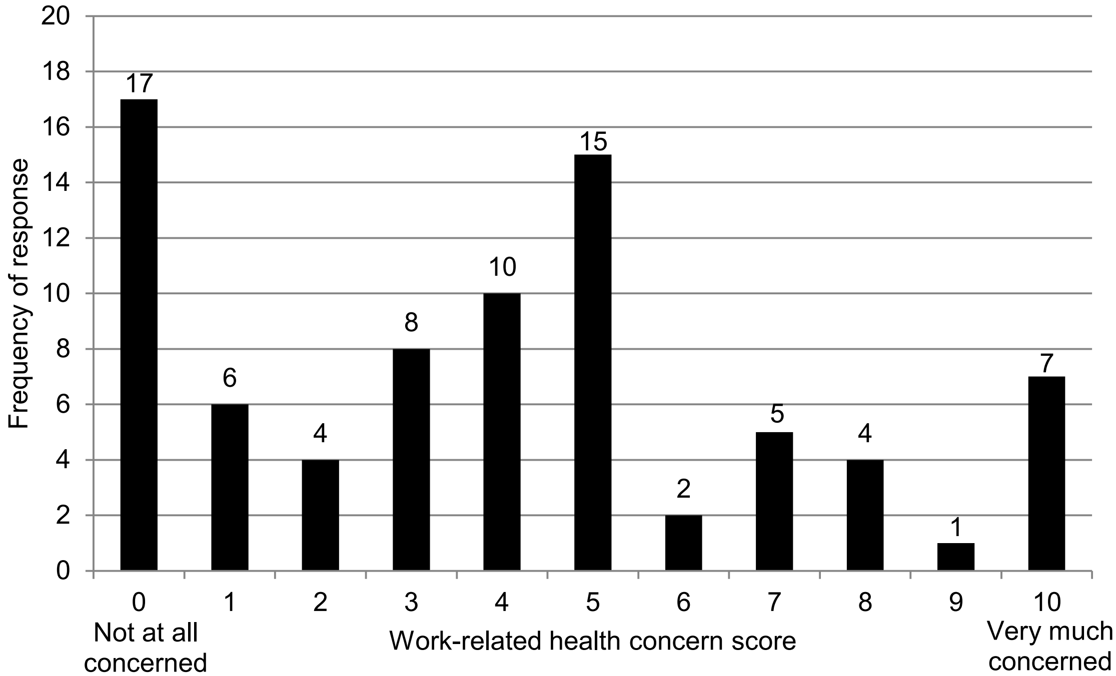


Figure 1. Frequency of reported work-related health concern scores (N = 79).

Using an open-ended question, participants were also asked to explain what their concerns were regarding workplace exposures and their potential impact on their health. Twenty-seven (34%) participants did not report a work-related health concern. Thirty-six (46%) employees reported concerns about potential long-term adverse health outcomes associated with working in a tire manufacturing plant and being exposed to a variety of chemicals. For example, 13 of the 36 (36%) employees who reported concerns about potential long-term adverse health outcomes specifically mentioned that the walls, plastic partitions, and other surfaces on the plant floor quickly became discolored when painted or replaced. These employees were concerned that whatever was causing the discoloration to happen may also be affecting them (e.g., by inhalation). We discussed this concern with plant managers. They were aware of this concern and had determined the discoloration was due to the deposition of sulfur-containing particulate onto these surfaces via impingement/electrostatic attraction. The company's industrial hygienists performed air sampling for sulfur-containing compounds and levels were below any occupational exposure limit (OEL). It was not clear whether this information was shared with employees.

### Safety Communication

The company maintained information about chemicals used in the plant in a material safety data sheet database that was accessible to all employees. Employees were required to participate in proactive safety activities (reporting hidden dangers, safety audits, and behavioral observations), and report these activities to their crew's safety coordinator. These safety activities were recorded in a database on the company's intranet computer system. At the time of this evaluation, employees were not receiving summary feedback on the proactive safety activities.

The company had safety coordinators (machine technicians and service technicians) on each crew. The safety coordinators were trained by the maintenance group leader and the safety service leader and met monthly to discuss health and safety issues raised by employees.

Employees were asked a series of yes/no questions regarding knowledge of accessible safety information, safety communication, and trust in the employer. These questions and the number and percentage of affirmative answers are included in Table 2.

Table 2. Safety communication interview questions (N = 79)

| Question | Number of participants answering "Yes" (%) |
|---|---|
| Do you know how to look up information on the chemicals you work with on the company's intranet? | 76 (96) |
| Do you believe management is approachable when it comes to reporting health concerns within the workplace? | 73 (92) |
| Do you trust management in protecting the well-being of employees? | 68 (86) |
| Are you satisfied with the communication between management and employees regarding health and safety issues in the workplace? | 72 (91) |

Nearly all employees interviewed reported that they knew how to look up material safety data sheet information on the company's intranet. Overall, interviewed employees' perceptions of health-related and safety-related communication were positive.

### Ventilation, Air Quality, and Air Circulation

Employees were asked a series of questions regarding ventilation and air circulation. Fifty-nine (75%) employees reported that the ventilation system in their work area was always on during their shift. Employees were also asked if the vents/louvers in their work area were always open during their shift since the employees making the health hazard evaluation request indicated that the vents would be manually closed by the company at different points through the day or workweek. Twenty-eight (35%) employees reported the vents/louvers were not always open, and questioned why this was the case. The plant managers reported that the vents/louvers would close at times based on air pressure differentials throughout the building, and that they were not being manually closed by the company.

Employees were also asked an open-ended question to describe the air circulation in their work area. Sixty percent of employees described the air circulation in a positive manner, while 29% described it negatively. Some employees (11%) responded that the air circulation varied from day to day or depended on the season. The percentage of employees reporting negative descriptions of air circulation differed by work area ($P = 0.02$), with the greatest proportion of negative descriptions reported by employees in Area 100 (mixing). Table 3 shows positive versus negative descriptions of air circulation by work area.

Table 3. Employees descriptions of air circulation in their work area

| Work area | Air circulation is fair to poor N (%) | Air circulation is good N (%) |
|---|---|---|
| Area 100 (N = 10) | 8 (80) | 2 (20) |
| Area 200 (N = 14) | 2 (14) | 12 (86) |
| Area 300 (N = 35) | 9 (26) | 26 (74) |
| Area 350 (N = 11) | 4 (36) | 7 (64) |

## Employee Health and Safety

All employees had preplacement health evaluations by the plant nurse. In addition, if they missed 3 or more days of work they were required to see the nurse upon their return and provide a physician's note. Certain jobs, such as mobile equipment operators, were re-evaluated every 2 years to document any new medical conditions that could impair their fitness for duty. The plant nurse reported that one current employee was known to have asthma and that it was non-occupational asthma aggravated by fragrances. The nurse also reported that three former employees had filed workers' compensation claims for respiratory illness in the last 5 years, but the claims had been denied by their insurance carrier. These records did not contain sufficient information to determine the work-relatedness of the respiratory illnesses.

Extensive medical records were reviewed for the two former employees we interviewed. Both of these employees had been diagnosed with asthma. Sufficient evidence in the medical records documented that one employee had asthma, but no relationship to the workplace could be established. The diagnosis of asthma was less clear in the other employee, and again, no relationship to the workplace could be established; however, it could not be ruled out. Both employees had onset of symptoms after working at the company and had no prior history of asthma. Evaluation by a physician knowledgeable in occupational medicine can be useful because most physicians are not familiar with occupational exposures in tire manufacturing.

While we did not assess cancer risk in this evaluation, the International Agency for Research on Cancer has classified occupational exposure in the rubber-manufacturing industry as carcinogenic to humans, with evidence for increased risk of leukemia; lymphoma; and cancers of the stomach, bladder, and lung [IARC 2012]. The International Agency for Research on Cancer states, "While it is clear that exposure to some agents in the rubber-manufacturing industry has been reduced over time, the results of recent cytogenetic studies continue to raise concerns about cancer risks." This makes it critical to reduce exposures to potentially carcinogenic rubber manufacturing chemicals (e.g., 1,3-butadiene) to the lowest feasible concentration.

### Occupational Safety and Health Administration Logs of Work-Related Injuries and Illnesses

We reviewed OSHA Logs for the past 5 years (2007–2012). Of 79 reported injuries, most were musculoskeletal (e.g., back or joint pain) or damage to the hands or fingers in addition to several eye injuries. No reported injuries were associated with respiratory damage or skin burns.

## Ventilation Assessment

The plant had general and local ventilation; these systems were reportedly designed in accordance with American Conference of Governmental Industrial Hygienists (ACGIH) and National Institute for Occupational Safety and Health (NIOSH) ventilation recommendations [NIOSH 1984; ACGIH 1995]. General ventilation was provided by 146 fans throughout the plant, which were supplemented by 34 heating and 31 air-conditioning units. A computer program monitored temperature and pressure in the building and automatically controlled all but one of the ventilation systems to maintain temperature and differences in pressure (relative to outdoors). The exhaust system for the tire curing line was not computer controlled and operated continuously. All ventilation systems and accessible gauges examined during our evaluation appeared operational. No unusual findings or damage were noted.

Preventive maintenance of the plant's general ventilation system was performed at 3 months, 6 months, and annually. Services routinely performed during preventive maintenance activities included filter changes, visual inspection of components, and airflow measurements. Additionally, a service technician was available on each shift to make nonroutine ventilation repairs.

Local exhaust ventilation was used at the mixing process, pigment compounding, steel ply machines, tire curing lines, and white sidewall grinding (among others). Employees performing these tasks checked either Magnehelic® or Photohelic® gauges daily to ensure the ventilation systems were operating within design specifications. If the gauge reading was not within design specifications, employees contacted the service technician to evaluate the ventilation system and make repairs or adjustments.

## Review of the Company's Industrial Hygiene Sampling Database

The industrial hygiene sampling database contains the results of measurements collected across the company's network of facilities. The database organized results by job title/work area and was a repository for historical industrial hygiene data dating back to the 1980s. This allowed managers to perform statistical trend analyses to compute the probability that exposures at jobs and processes may have exceeded OELs. For a given job, three full shift samples, on different days, were collected in the breathing zone of the employee. The sample results were added to the database and compared to historical measurements for the same job. Probability statistics such as the mean (average) value and the 95% upper confidence limit were computed and compared to the most stringent applicable OEL [NIOSH 1977].

Sample results were also examined relative to historical measurements to determine trends and the need for resampling. The company used the relative ranking of the mean value to determine the frequency of future sampling for the specific job/task/process. For example, the closer the sample results were to an applicable OEL (95% upper confidence limit), the more frequently sampling occurred. Conversely, as the sample results moved farther away from the OEL, less frequent sampling was required. In general, sampling was conducted quarterly, annually, every 3 years, or every 5 years, depending on the exposure levels measured.

In the rare case that an OEL was exceeded, the health and safety department evaluated the process, work practices, and engineering controls to determine the cause of overexposure. If a change in a workplace condition or process occurred, additional sampling was performed to determine whether employee exposure had changed. For example, if an engineering control had been altered or implemented, additional samples were collected on employees to determine the effect, if any, of such a change. Additional sampling was performed quarterly to monitor the effectiveness of the change. Because employees worked 12-hour shifts, all OELs were adjusted according to the Brief and Scala method [ACGIH 2013]. The most common air contaminants in the tire manufacturing industry that were measured in the plant were: formaldehyde; rubber curing fume (measured gravimetrically); total particulate; respirable particulate; carbon black; amorphous silica;1,3-butadiene; chromium; heptane; and resorcinol. While some of these contaminants were detectable over the last five years, none exceeded the OEL(s).

# Conclusions

The company had created a comprehensive industrial hygiene monitoring program and a useful computerized database. The ventilation systems at this plant were in good working order and appeared adequate for reducing employee exposure to air contaminants based on observation and review of the most recent 5 years of sampling data. Most interviewed employees reported low levels of concern about their work-related health and nearly all reported knowing how to get information about chemical exposures. Some communication gaps may have existed regarding the operation of the ventilation systems and the industrial hygiene monitoring program. No adverse respiratory health conditions were definitively linked to work in this plant on the basis of review of medical records and OSHA Logs.

# Recommendations

On the basis of our findings, we recommend the actions listed below. We encourage the tire manufacturing company to use a labor-management health and safety committee or working group to discuss our recommendations and develop an action plan. Those involved in the work can best set priorities and assess the feasibility of our recommendations for the specific situation at the tire manufacturing plant.

1. Communicate exposure measurement results using plain language to affected employees. Provide employees with a point of contact for addressing questions or concerns about exposures.
2. Explain to employees why sulfur-containing particulate compounds can cause staining of the walls, plastic strip curtains, and other materials (e.g., paper) in the production areas, and if it has the potential to affect their health.
3. Explain to employees how the ventilation systems operate and why the ceiling vents may open and close during the workday.
4. Give employees regular (e.g., quarterly) feedback on their proactive safety activities to include a description of the nature and frequency of the reported concerns, and what, if anything, will be done to address the concerns.
5. Refer employees who report possible work-related respiratory conditions to an occupational medicine physician. You can locate these physicians in your area at http://www.aoec.org.
6. Encourage employees to learn about known cancer risk factors, measures to reduce risk for preventable cancers, and availability of cancer screening programs for certain types of cancer. The American Cancer Society posts information about cancer on its website at http://www.cancer.org/. For general information, click on the "Learn About Cancer" tab at the top of the webpage. For information about a specific type of cancer, click on "Show All Cancer Types," under the "Learn About Cancer Topics" sidebar. Additionally, NIOSH posts information about occupational cancer and cancer cluster evaluations on its website at http://www.cdc.gov/niosh/topics/cancer/. Employees can take an active role in changing personal risk factors that are associated with certain types of cancer. You can help them by encouraging use of the onsite fitness facility, providing healthy food in the cafeteria and vending machines, and banning smoking from the entire facility and grounds.

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## Availability of Report

Copies of this report have been sent to the employer, employees, and union at the plant. The state and local health department and the Occupational Safety and Health Administration Regional Office have also received a copy. 

This report is available at http://www.cdc.gov/niosh/hhe/reports/pdfs/2012-0114-3185.pdf.


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