HETA 89-030-2198
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DELCO REMY
OLATHE, KANSAS

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I. SUMMARY

On February 15, 1989, the National Institute for Occupational Safety and Health (NIOSH) conducted a Health Hazard Evaluation at the Delco Remy battery plant in Olathe, Kansas. The survey was conducted at the plant in response to employee complaints, particularly employees in the Paste Department. Employees reported symptoms, such as headache, sore throat, dizziness, light-headedness, irritated eyes, and stomach ache. Employees also reported odors coming from the supply air ventilation system described as exhaust fumes, rotten sewer smells, burned paint, paint thinner, unburned natural gas, vinegar, and alcohol. Complaints began shortly after many of the plant air handling units (AHUs) were converted from steam coil to direct-fired heating.

Sampling was conducted at the plant for aldehydes, carbon monoxide and dioxide, nitrous oxides, hexane, and pentane. Samples were collected down stream of the burner and a cooling coil in the AHU serving the Paste Department, in the Paste Department, and in other locations of the plant serviced by other AHUs. One unit, not in the main complaint area, was set on high-fire to check for contaminants under extreme conditions. Sample results showed that none of the contaminants for which sampling was performed exceeded standards or recommendations under any conditions.

During inspection of the unit serving the Paste Department, the burner was found to be rapidly cycling between low fire and high-fire instead of modulating slowly. The rapid cycling produced a sour odor due to incomplete combustion of the natural gas. In addition, measurements of the relative humidity (RH) outdoors and inside the AHU illustrated that the RH of the air decreased from nearly 100% to about 30% after heating. The results of the humidity measurements and other observations lead to speculation that on colder, drier days, the RH in the plant may be much lower, causing thermal comfort-related problems. Inspection of two of the AHUs also identified maintenance problems. Results from the inspection of the air-handling units (AHUs) and other observations showed that an unidentified odor was being generated by the burner on the direct-fire system in the AHU serving the Paste Department. Results also show that low relative humidity in the plant is possible during colder, drier times of the year leading to thermal comfort complaints.

Key Words: SIC CODE: 3694 (Electrical Equipment for Internal Combustion Engines), lead-acid batteries, carbon monoxide, carbon dioxide, nitric oxide, nitrogen dioxide, formaldehyde, hexane, pentane, relative humidity, maintenance, ventilation.

II. INTRODUCTION

In November 1988, the National Institute for Occupational Safety and Health (NIOSH) received a Health Hazard Evaluation request from United Auto Workers (UAW) Local 1021 at the Delco Remy Plant in Olathe, Kansas. Shortly after converting the steam heating coils in the air-handling units (AHUs) serving the plant to natural gas direct-fired burners, plant employees began complaining of odors coming from the ventilation system. Symptoms include headache, sore throat, dizziness, light-headedness, irritated eyes, and stomach ache. On February 14 and 15, 1989, NIOSH conducted a survey at the plant. During the survey, one area in particular, the Paste Department, appeared to have more employees with complaints. Therefore, most of the survey activities centered around this area.

Conclusions based on observations and indicator tube measurements were presented to management, union, and first-shift Paste Department employees at the end of the survey. Eight hour sample results were presented to management and union personnel by phone in May 1989.

III. BACKGROUND

Lead acid batteries, primarily for automobiles, are produced at the Delco Remy plant. Virtually the entire manufacturing process occurs in the plant except extrusion of the plastic cases. Reportedly, the area whose employees complained most often was the Paste Department. In this department, a series of manufacturing lines place lead paste on the battery plates. The plate molding and pasting process is virtually automatic except at the end of the process line where employees inspect, remove, and stack the plates on pallets to be transported to other areas of the plant. Most of the complaints in the department were reported to come from the employees performing the inspection jobs.

Air is supplied to the Paste Department by a large (58,000 cubic feet per minute (cfm)) air handling units (AHU). Duct drops with louvered registers supply the air directly over the heads of the employees working on the process lines in this department. The duct drops terminate about 10 feet above the floor. Each drop has a damper system with a chain attached to the damper handle so employees can adjust the volume of air flow. This AHU was originally equipped with a roll filter, steam heating coil, chilled water cooling coil, and fan. In addition, supply air to the plant was originally a mixture of return and outside air. For economic reasons, the steam heating coils from most of the AHUs servicing the plant, including the unit serving the Paste Department, were replaced with direct-fire burner assemblies. Because the manufacturer recommended that recirculated air not pass over the direct- fire burner, control systems were added so the units were supplying 100% outside air during occupied hours.

Direct-fire systems heat the air by burning gas directly in the air supplied to the plant. Combustion occurs entirely in the AHU. In theory, confirmed by independent research[1] and manufacturer experience with actual installation, unburned gas and by-products of combustion do not reach levels which threaten health and safety because of the large volume of air passing through the AHU. Calculations by NIOSH verified that unburned gas would not reach an explosive concentration should the burner fail to light.

Several parameters of the system are critical to assure that the gas burns properly in the air stream. These include the air velocity across the burner, gas pressure, and the temperature of the air. Gas velocity and pressure are important for the proper mixing of gas and air for combustion. Temperature is critical because the gas/air mixture needs to be within certain temperature limits for proper and efficient ignition. To assure safe operation of the direct-fire heating system, redundant safety systems for air flow, proof of flame on the burner, and high and low air temperature are incorporated in the system. In addition, specially designed baffles are added to the burner to achieve proper burn.

The major component of natural gas is methane (>83% by volume). Other components which may be present, depending on where the gas originated, are hydrogen, ethylene, ethane, carbon monoxide (CO), carbon dioxide (CO_2), nitrogen, oxygen, and hydrogen sulfide.[2] Ideally, complete combustion of clean natural gas produces CO and water. Incomplete combustion can produce byproducts, such as aldehydes (including formaldehyde), CO, combined nitrogen compounds, and other hydrocarbons, including unburned natural gas.[3]

IV. METHODS

On February 13-14, 1989, NIOSH investigators collected full-shift area air samples for CO, NO_2, nitric oxide, formaldehyde, *n*-hexane, and *n*-pentane. Direct-reading colorimetric detector tubes also were used to measure CO, NO_2, formaldehyde, and methane. CO_2 was measured using a Gastech™ Model 3252 direct-reading instrument. Air samples were collected in process areas, an office area, outdoors, and inside several AHUs. Samples were collected mostly with the AHUs operating normally for the outdoor climatic conditions. However, on the 14th, one AHU of comparable capacity to the unit serving the Paste Department and serving an area of the plant with few employees, was manually set on high-fire to try to replicate worst-case conditions.

Full-shift air samples were collected and analyzed by the following methods:

A. <u>Carbon Monoxide</u>

Ten full-shift air samples were collected on Draeger colorimetric long-term detector tubes using battery-powered sampling pumps at a flow rate of 0.02 liters per minute (lpm).

B. Nitrogen Dioxide

Fourteen full-shift air samples were collected on passive (Palmes) tubes containing three triethanolamine-treated screens. The samples were analyzed by visible spectroscopy according to NIOSH Method 6700.[4]

C. Nitric Oxide

Fourteen air samples were collected on Palmes tubes, containing three triethanolamine-treated screens and a chromic acid impregnated disc. This "NO plus NO_2" sampler was designed to convert any NO present into NO_2 (by reaction with the chromic acid). The NO_2 formed by this reaction was collected along with the native NO_2 on the triethanolamine-coated screens. These samples were collected in paired side-by-side sets with the NO_2 Palmes tubes.

D. Formaldehyde

Fourteen full-shift air samples were collected on ORBO™-22 sorbent tubes at a flow rate of 0.05 lpm. The samples were desorbed with isooctane and analyzed by gas chromatography/flame ionization detection (GC/FID) according to NIOSH Method 2502.[4]

E. *n*-Hexane and *n*-Pentane

Fourteen air samples were collected on 150 milligram (mg) charcoal tubes at a flow rate of 0.05 lpm for seven hours. The samples were desorbed with carbon disulfide and analyzed by GC/FID according to NIOSH Method 1500.[4]

V. EVALUATION CRITERIA

As to guide the evaluation of the hazards posed by workplace exposures, NIOSH field staff employ environmental evaluation criteria for assessment of several chemical and physical agents. These criteria are intended to suggest concentrations of exposure to which most workers may be exposed up to 10 hours per day, 40 hours per week for a working lifetime without experiencing adverse health effects. It is; however, important to note that not all workers will be protected from adverse health effects if their exposures are maintained below these limits. A small percentage may experience adverse health effects because of individual susceptibility, a preexisting medical condition, and/or a hypersensitivity (allergy).

In addition, some hazardous substances may act in combination with other workplace exposures, the general environment, or with medications or personal habits of the worker to produce health effects, even if the occupational exposures are controlled at the limit set by the evaluation criterion. These combined effects are often not considered in the evaluation criteria. Also, some substances are absorbed by direct contact with the skin and mucous membranes, and thus potentially increase the overall exposure. Finally, evaluation criteria may change over the years as new information on the toxic effects of an agent become available.

The primary sources of environmental evaluation criteria for the workplace are the following: 1) NIOSH Criteria Documents and recommended exposure limits (RELs)[5], 2) the American Conference of Governmental Industrial Hygienists' (ACGIH) Threshold Limit Values (TLVs)[6], and 3) the U.S. Department of Labor, Occupational Safety and Health Administration (OSHA) permissible exposure limits (PEL).[7]

A time-weighted average (TWA) exposure refers to the average airborne concentration of a substance during a normal 8- to 10-hour workday. Some substances have recommended short-term exposure limits (STELs) or ceiling values which are intended to supplement the TWA where there are recognized toxic effects from high short-term exposures.

The evaluation criteria and adverse health effects caused by overexposure to the substances investigated during this evaluation are presented in Table 1.

VI. RESULTS AND DISCUSSION

A. Carbon Monoxide

Full-shift TWA concentrations of carbon monoxide (CO) ranged from 8 to 13 parts per million (ppm) in the work areas (Tables 2 and 3). The CO concentration was 10 ppm in the air from the mezzanine AHU during the "high-fire" test on February 14. During normal operation, the AHUs had full-shift CO concentrations ranging from 4 to 9 ppm with a mean of 6 ppm. The NIOSH 8-hour REL and OSHA PEL for CO is 35 ppm[5,7] while the ACGIH TLV is 50 ppm[6]. The NIOSH and OSHA ceiling limit for CO is 200 ppm[5,7] while the ACGIH STEL is 400 ppm[6].

Short-term CO concentrations in work areas ranged up to 10 ppm while forklifts were operating nearby and averaged about 5 ppm when there was no forklift activity. Six short-term CO measurements taken inside the AHUs during normal operation were all 5 ppm.

B. Nitrogen Oxides

Full-shift nitrogen dioxide (NO_2) concentrations (using Palmes tubes) in the work areas and inside the normally operating AHUs ranged from 0.1 to 0.2 ppm (Tables 2 and 3). Three-tenths ppm of NO_2 was found in the "high-fire" test in one AHU. Short-term measurements of NO_2 (using detector tubes) were non-detectable (less than 0.5 ppm). The NIOSH recommended and OSHA STEL for NO_2 is 1 ppm as a 15-minute ceiling concentration. The ACGIH TWA exposure limit and STEL for NO_2 are 3 and 5 ppm, respectively.

Results from the "NO + NO_2" tubes were lower than those found in the NO_2 tubes. Review of the analytical results indicates a possible laboratory problem. Therefore, the NO results are inconclusive.

C. Formaldehyde, *n*-Hexane, *n*-Pentane, and Methane

Formaldehyde, *n*-hexane, or *n*-pentane were not detected in the full-shift samples. The sampling and analytical limits of detection were 0.04 ppm for formaldehyde and 0.2 ppm for *n*-hexane and *n*-pentane.

No formaldehyde (less than 0.5 ppm) or methane (less than 0.5%) were detected in the short-term samples.

D. Carbon Dioxide

Carbon dioxide (CO_2) concentrations inside the AHUs ranged from 600-1,500 ppm during normal operation and ranged up to 3,000 ppm during the "high-fire" test. CO_2 concentrations in the work areas ranged from 800 to 1,400 ppm. The outdoor CO_2 concentration was 250 ppm. The NIOSH and ACGIH RELs for CO_2 is 5,000 ppm[5, 6]. The OSHA PEL is 10,000 ppm[7].

E. Observations

The following observations were made during the survey:

1. The AHU servicing the Paste Department (AHU 2N) and one other unit (AHU 2S) were housed in the same penthouse on the roof of the plant. During inspection of these AHUs, a difference in the operation of the burner was noted. AHU 2N's burner cycled rapidly from low- to high-fire (as judged by flame length and noise from the burner), while AHU 2S's burner operated relatively constantly. Inside of AHU 2N downstream of the burner, a sour odor was generated every time the burner cycled to high-fire. This odor was believed to be due to incomplete combustion of natural gas because the burner cycled to high-fire so fast that all the gas was not being burned.

None of the sample results showed an increase in contaminant concentrations caused by incomplete burn. One reason for this is believed to be that the short duration of the change from low to high-fire (only a few seconds) and the large volume of air passing through the AHU made average concentrations very low. Such low concentrations would not show up in the sample results. Even though the concentrations were too low to be shown by the samples, the concentrations were above the odor threshold for the contaminant.

During the survey, the plant engineer verified problems of low gas pressure in the manifold, and improper adjustment of part of the control system in the direct-fire system for the burner. After the gas pressure and control system were adjusted to match the settings for comparable AHUs, AHU 2N's burner was reported to not cycle.

The odor generated by the burner going to high-fire too rapidly is believed to be the odor reported by the employees. Descriptions of the odor and the occurrences corresponded to the rapidly cycling burner findings in AHU 2N.

2. Relative humidities (RHs) measured around the Paste Department ranged between 34 and 58%. Humidities inside AHU 2N, downstream of the cooling coil during high-fire, ranged from 29 to 45%. Outdoor humidity readings were nearly 100% with a temperature around freezing. The direct-fire systems are designed for a maximum temperature rise of about 100 °F. On very cold days, when the outside air is heated 100 °F, the RH in the plant can drop very low, depending on the humidity of the outside air.

   In the past, plant air, along with moisture added from processes, was recirculated. With the use of direct-fire systems, no plant air is recirculated. Most of the plant air, along with the moisture added to the plant air by the processes, is exhausted outside.

   Evidence that humidity levels in the plant were lower with the direct-fire systems was presented by process problems in the Paste Department. In part of the plate-making process, "plate curing," the plates from the Paste Department are stored for a period of time to let a chemical reaction complete. After installation of the direct-fire systems, problems occurred because the plates dried too quickly. The solution to the problem was to add humidification systems to the plate curing room.

   Low humidity in the plant during colder days could cause employees to experience problems with dry mouths and throats.

These symptoms could probably be exacerbated by dry air being blown directly on the employees.

3. Another potential source of odor and irritant problems could be the propane-powered forklift trucks used to move the plates from the Paste Department. General air movement in the Paste Department was toward the ovens on the paste lines. Exhaust emissions from the forklifts passed directly through the employee-occupied area at the end of the line. Some operations require forklifts to stay in the area for long time periods and also require the forklifts to rev up the engines to lift loads. In addition, drivers tend to park their forklifts in the area at the end of the line while keeping their forklifts' engines running. In such cases, emissions from the forklifts can last for substantial amounts of time.

4. Employees were able to adjust the volume of supply air blowing on them. However, whenever one employee would change his or her air flow, the air flow to the other employees also changed because all the duct drops were connected to a common system.

5. Return air is not supposed to pass over the burners in direct-fire systems. In the air handlers at the plant, the arrangement of the burners in the unit did not make recirculation possible because the burners were downstream of the return air damper and there was no room to relocate the return air damper to downstream of the burner. A hand-operated control system was put in to manually operate the recirculation dampers when the plant was not occupied, such as during weekends, apparently for energy control purposes. Reportedly, the return air dampers on some units were found open during occupied times.

6. During an inspection of several AHUs, the units were found to be dirty. The operability of the roll filters was questionable. Filtration of the air entering direct-fire burners is important because airborne particles can clog the holes in the baffle plates on the burner. Clogged holes can cause the velocity of the air flowing across the burner to change, affecting the efficient burning of the gas. In addition, particles in the air can affect the burn efficiency.

   Other signs of poor maintenance were also evident. Examples were rust on the inside of the units, particularly on the fans; AHU 2S's fan knocked off its mounting; and torn gasketing between the fan and the floor.

VII. CONCLUSIONS

No hazard from overexposure to any combustion products of direct-fired gas heaters was identified at the time of the NIOSH visit. Emissions of combustion products during the simulated "worst-case" conditions of the high-fire test were also found to be below the NIOSH recommended exposure limits. However, cycling of the burner in AHU 2N, which generated possibly offensive and irritating odors, and low humidity were suspected to be the causes of many of the employees' complaints. Emissions from forklift trucks could further contribute to employees' complaints.

VIII. RECOMMENDATIONS

1. All the direct-fire control systems should have a routine maintenance schedule. Included in this schedule should be an inspection, cleaning, and calibration of the control systems. All components of the AHUs should be inspected for correct operation and condition. Problems found during this inspection should be repaired. The interiors of all the units should be routinely cleaned. A routine maintenance schedule should be developed for all the components of the AHUs in consultation with the manufacturers of the components. Repair of any problems found during routine maintenance or found because complaints should be given equal priority with production equipment.

2. The current air supply system in the Paste Department should be refurbished. A supply system which decreases the velocity of the air on the employees should be installed. Not only would the employees benefit from the lower velocity, the operation of the nearby exhaust ventilation systems would be less affected by the supply air flow. In addition, the supply systems should be renovated so changes in the air flow at any outlet will not affect the air flow to other outlets.

3. Plant air should not be recirculated through the AHUs. To this end, control systems should be installed so only specified people can operate recirculation systems. Recirculation damper motors should be removed, or recirculation dampers should be mechanically obstructed so they do not work.

4. Ways to decrease forklift truck exhaust from passing through the Paste Department employees' area should be investigated. Some methods include using battery-powered fork trucks, turning off fork trucks when waiting for work, scheduling movement of battery plates during worker breaks, or physically isolating processes which require fork trucks to operate for extended periods of time with the engine operating at high speed.

IX. REFERENCES

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5. OSHA, Region VII

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TABLE 1

Evaluation Criteria for Hazardous Substances
Delco Remy
Olathe, Kansas

HETA 89-030

Contaminant	OSHA PEL[1]	ACGIH TLV[2]	NIOSH REL[3]	Principle Health Effects
Carbon Monoxide (CO)	35 ppm	50 ppm	35 ppm	CO interferes with the oxygen carrying capacity of the blood. Signs of acute poisoning are headache, dizziness, drowsiness, nausea, and vomiting.
Carbon Dioxide ($C0_2$)	5000 ppm	5000 ppm	5000 ppm	CO_2 is a simple asphyxiant. 50,000 ppm may cause shortness of breath and headache.
Nitrogen Oxides NO_2 NO	 1 ppm (15 min ceil.) ---	 3 ppm ---	 1 ppm (15 min. ceil.) 25 ppm	High acute exposure causes severe respiratory irritation that may result in pulmonary edema. Chronic exposure may cause obstructive lung disease.
Formaldehyde	1 ppm	1 ppm	lowest feasible concentration	Eye, nose and throat irritation. NIOSH considers formaldehyde to be an occupational carcinogen.
n-Hexane	50 ppm	50 ppm	50 ppm	Upper respiratory irritation, headache, dizziness. May cause peripheral neuropathy.
n-Pentane	600 ppm	600 ppm	120 ppm	Upper respiratory irritation, headache, dizziness.
Methane	---	---	---	Methane is a simple asphyxiant. 100,000 ppm can cause death due to oxygen deficiency.

[1]Permissible Exposure Limit
[2]Threshold Limit Value
[3]Recommended Exposure Limit

TABLE 2

Air Sampling Results for Carbon Monoxide (CO) and Nitrogen Dioxide (NO_2) in ppm

Delco Remy
Olathe, Kansas
February 14, 1989

HETA 89-030

Location	**Sample Time**	**CO**	**NO_2**
1403 Formation Fill High-Fire Test #2 (Make-up air from the Mezzanine Air-Handling Unit)	1640-2340	10	0.3
2 North Air-Handling Unit	1605-2240	5	0.1
2 South Air-Handling Unit	1615-2240	5	0.1
1453 X-Met. #1 Off Bear	1536-2255	---	0.2
1453 X-Met. #2 Off Bear	1645-2300	8	0.2
Conference Room	1520-2310	1	0.03
Outdoors	1550-2240	1	N.D.[1]
Evaluation Criteria		35	1.0 (15 min. ceiling)

[1]N.D. = None Detected (less than 0.01 ppm)

TABLE 3

Air Sampling Results for Carbon Monoxide (CO) and Nitrogen Dioxide (NO_2) in ppm

Delco Remy
Olathe, Kansas
February 15, 1989

HETA 89-030

Location	**Sample Time**	**CO**	**NO_2**
1403 Formation Fill High-Fire Test #2 (Make-up air from the Mezzanine Air-Handling Unit)	1600-2240	9	0.2
2 North Air-Handling Unit	1615-2220	6	0.2
2 South Air-Handling Unit	1610-2220	4	0.1
1453 X-Met. #1 Off Bear	1620-2240	---	0.2
1453 X-Met. #2 Off Bear	1625-2240	13	0.2
Conference Room	1510-2305	---	N.D.[1]
Outdoors	1550-2240	---	N.D.
Evaluation Criteria		35	1.0 (15 min. ceiling)

[1]N.D. = None Detected (less than 0.01 ppm)