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RELIANCE ELECTRIC

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I. SUMMARY

In August 1993, the National Institute for Occupational Safety and Health (NIOSH) received a Health Hazard Evaluation (HHE) request from the International Association of Machinist and Aerospace Workers, to evaluate cancer among employees at Reliance Electric (Reliance) located in Madison, Indiana. A list, prepared by a past local union officer, of 77 names of suspected cancer cases accompanied the request. On December 17, 1993, an initial site visit was conducted to evaluate work processes and employee exposures and to interview employees. A follow-up visit was made February 22, 1994, to complete employee interviews and collect air samples.

NIOSH investigators reviewed death benefits and employee medical records to verify cancer cases. Of the 77 reported cancer cases only 45 could be verified through available records. The observed and expected number of cancer cases for Reliance employees were compared. Based on estimated cancer incidence rates for Indiana, a crude calculation indicated an excess in cases of melanoma and pancreatic cancer.

NIOSH investigators interviewed 43 employees. The most frequently reported symptoms (eye, nose and throat irritation, and headaches), were nonspecific; that is, they could be caused by any of a number of factors including, but not limited to, chemical exposures. Employees attributed symptoms to such exposures as fumes from paints, the Young Brothers Oven emissions, and xylene

A number of back injuries and disorders attributable to repetitive trauma (Dart) were noted on the OSHA Summaries of Injuries and Illness (Form 200). Fifteen of 27 reported DARTs and eight of 19 reported back injuries were recorded from occupational code 701, Winding.

General area air sampling for formaldehyde revealed exposures which ranged from a traced concentration measured outside the building to 0.017 parts per million (PPM) measured in a sample collected on the table by the scratch brush in the Winding area. Titanium dioxide measured in personal breathing zone (PBA) samples on painte the rotor cast operator ranged up to 0.003 milligram per cubic meter (mg/m3). With the exception of exposure to formaldehyde and titanium dioxide above their NIOSHts (RELs) of lowest feasible limit (LFL), the NOISH industrial hygiene sampling did not reveal overexposure to any of the compounds sampled. The walkthrough tour of the plant revealed some deficiencies in the ventilation system and the respiratory protection program. The outdated material safety data sheet (MSDS) the company had on hand for the Non-Toxic-Green paint indicated a problem with the Hazard Communication

Program. In light of the nickel exposure documented by the company, the effectiveness of the local exhaust ventilat6ion used when welding nickel-containing alloys should be assessed.

It is unlikely that the cases of melanoma or pancreatic cancer can be attributed to the environment of Reliance Electric; there was no identified carcinogen currently in the workplace that is known to cause these types of disease. There was an apparently elevated risk of musculoskeletal disorders due to repetitive trauma and back injuries in the occupational code 701, Winding. Nonspecific symptoms reported by employees such as eye, nose and throat irritation, and headaches could result from the listed exposures as well as from the environmental tobacco smoke found inthe workplace. Recommendations for the corrective action are located in Part VII of this report.

Keyword: SIC 3621 (Motors and Generators) cancer cluster, pancreatic cancer, melanoma, electric motors, xylene, formaldehyde, titanium dioxide, nickel

II. INTRODUCTION & BACKGROUND

In August 1993, the National Institute for Occupational Safety and Health (NIOSH) received a request from the International Association of Machinist and Aerospace Workers for workers at Reliance Electric (Reliance) located in Madison, Indiana. The requester was concerned about suspected cancer excesses among employees. A list initiated by a past local union officer of 77 names of suspected cancer cases accompanied the request.

On December 17, 1993, an initial site visit was conducted to evaluate work processes and employee exposures and to interview employees. A follow-up visit was made February 22, 1994 to complete employee interviews and collect air samples.

The Reliance Electric plant in Madison, Indiana, manufactures electric motors ranging in size from one-quarter to five horsepower, and employs approximately 430 workers. The plant was constructed in 1962 and occupies over 2,000 square feet (sq ft) including office space. The workforce of 430, including management personnel, has been stable since 1974.

Reliance operates two shifts, seven days a week. A plant nurse is available on day shift, Monday through Friday. The company physician is a local practitioner.

Process Description

The manufacturing of electric motors at Reliance is a multi-step process. Shafts are cut to length, centered, and machined in one of two lines. Rotors are manufactured by stacking laminations, which are then cast with aluminum on the four cavity die cast machine (rotorcast). The rotors are then broached, and machined on a lathe to define the outside diameter. The rotors are then heated and the shaft is driven in. Heating takes place in a Selas oven or in an induction heater. Together, the shaft and rotor form the rotating assembly. End shields are either machined or purchased. Motor frames begin as rolls of steel, which are cut to size, folded over, and welded. Punch presses are used to produce fan covers and conduit boxes for some motors. Stators are cleated and insulated. Copper wire is wound into coils and inserted into stator cores. Cleated and insulated windings mated with the coil are then varnished. There are two different varnish dipping operations for the stators: hand dipping and machine-applied varnish using the Young Brothers machine. In either case, varnished stators are then baked in an oven. Single-dipped stators have their interior diameter ground to size on a grinding table. Multiple-dipped stators are manually ground. The grinding tools are known as scratch brushes.

The various parts are then assembled either in regular assembly, where each assembler puts together each motor, or the parts are loaded on a tray and sent to Progressive Build,

a nine position line where each operator performs one or two operations and passes the motor on to the next station. While some pieces are painted as they are completed, and some rotors receive a primer coat, most painting takes place after assembly.

III. EVALUATION METHODS

(a) Medical Methods

Confidential interviews were conducted with 43 workers. Participants were asked to describe information on work (e.g., date of hire, department, length of employment) and health (e.g., symptoms of eye, nose, or throat irritation, headaches, and medical history of allergies or asthma). In addition, Occupational Safety and Health Administration (OSHA) Form 200 logs (summaries of occupational injuries and illnesses) from January 1990 through February 16, 1994 were reviewed. Finally, four death certificates were requested with two received and reviewed.

(b) Industrial Hygiene Methods

The MSDS for the varnish in use at the time of the survey indicated that the product releases formaldehyde as it cures. Four general area (GA) air samples for formaldehyde were collected and analyzed in accordance with NIOSH Method 3500.[1] Samplers were placed near the scratch brush in the winding area, near the scratch brush in the 701 dip room (near the Young Brothers machine) and on the desk by the hand-dip tanks in the 701 dip room. One of the samples was collected outside the plant to measure the background concentration in order to establish the LFL. Samples were collected with midget impingers containing approximately 15 milliliters (mL) of 1% sodium bisulfite solution. Each impinger was preceded by a tared 37-millimeter (mm) diameter, 5-micrometer (µm) pore-size polyvinyl chloride (PVC) filter in order to exclude formaldehyde-containing particulate from the impinger, and thus prevent a positive bias. Tygon tubing was used to connect the filter cassette to the impinger, and to connect the impinger to a battery-powered sampling pump calibrated at a flow rate of one liter per minute (L/min). The analytical limit of detection (LOD) for this set of samples was 0.3 micrograms µg/ sample, which equates to a minimum detectable concentration (MDC) of 0.0007 (ppm), based upon the maximum sample volume of 343 liters for this set of samples. The minimum quantifiable concentration (MQC) for this sample set was 0.002 ppm, based upon an analytical limit of quantitation (LOQ) of 0.89 µg/sample, and a maximum sample volume of 343 L.

In order to assess the degree of total particulate (e.g., dust produced by the scratch brushes) exposure, the PVC filters were analyzed according to NIOSH Method 0500 with modifications.[1] These modifications included: 1) the backup pads and filters were not vacuum desiccated, 2) the filters were stored in an environmentally

controlled room (21 ± 3 °C and 50 ± 5% Relative Humidity), and subjected to the room conditions for at least several days duration prior to tare weighing for stabilization. This reduces the method's 8- to 16-hour time for stabilization between tare weighings to 5 to 10-minutes. 3) The filters with dust were not vacuum desiccated 15-minutes prior to final weighing. The LOF of this method, 0.02 milligrams (mg), was based upon studies of the physical integrity of various PVC filters, which have shown that the weight of the filter may vary by as much as 0.02 mg.

Two full-shift PBZ air samples were collected and analyzed for formaldehyde in accordance with NIOSH Method 2541 with modifications.[1] Samples were collected on solid sorbent tubes (10% 2-[hydroxymethyl] piperidine on XAD-2 resin) in plastic holders connected via a length of Tygon tubing to battery-powered personal sampling pumps operating at a flow rate of 100 milliliters per minute (mL/min). Sampling was performed in the breathing zones of Young Brothers operator and the scratch brush operator in the winding area. In order to collect PBZ air samples representative of potential formaldehyde exposures, the pumps were attached to a belt at the employee's waist, while the sorbent tube holder was attached to the employee's lapel. Pumps used to collect PBZ air samples were turned off during the lunch break. The analytical LOD for this sample set was 0.4 µg/sample, which equates to a MDC of 0.008 ppm, based upon the maximum air sampling volume for this set of samples, 39.2 L. The LOQ for this sample set was 1.3 µg/sample, which equates to a MQC of 0.027 ppm, based upon a maximum sample volume of 39.2 L.

Two full-shift PBZ air samples for formaldehyde on dust were collected on the employees who were asked to wear the formaldehyde samplers. As with the PBZ air samples for formaldehyde, the employees wore sampling pumps on belts at their waist, with the sampling device attached to their lapels. Samples for formaldehyde on dust were collected on tared 25-mm diameter, 5 µm pore size PVC filters placed in personal samplers for inhalable dust. These samplers collect inhalable (inspirable) particles in the size range which represents the dust the worker takes in through the nose and mouth during the act of breathing, i.e., particles with an aerodynamic diameter up to 100 µm.[2,3] Inhalable particles have been described as those that can be deposited anywhere in the respiratory tract.[3] The samplers were connected via Tygon tubing to battery-powered sampling pumps operating at a flow rate of 2 L/min. The pumps were turned off at lunch time. Samples collected in this manner were analyzed using NIOSH Method 5700. The LOD for this sample set was 0.77 µg/sample, or a MDC of 0.98 micrograms ($\mu g/m^3$) for a sample volume of 784 L, the maximum sample volume for this set of samples. The MQC for the NIOSH method for this sample set was 3.27 $\mu g/m^3$, based upon a LOQ of 2.56 µg/sample and a sample volume of 784 L.

Five full-shift PBZ air samples for metals were collected and analyzed by inductively coupled plasma atomic emission spectroscopy (ICP-AES) according to NIOSH Method 7300, modified for microwave digestion.[1] Samples were collected in the breathing zones of the rotor cast operator, both painters painting frames at the booth in department 719, the painter painting motors at the booth in department 707, and the painter painting rotating assemblies at the booth in department 716. The sampling was performed using 37-mm diameter, 0.8-micro meter (µm) pore-size mixed cellulose ester filters in three-piece cassettes, connected to a battery-powered sampling pump via a length of Tygon tubing. Samples were collected at a flow rate of 2 L/min. The pumps were turned off at lunch time. Table 1 provides a list of the metals of concern which were analyzed by this method, along with the analytical LOD, analytical LOQ, MDC, and MQC. The MDC and MQC are based upon the maximum sample volume for this sample set of 790 L.

Two consecutive partial-shift PBZ air samples were collected in the breathing zones of each of the painters working at the 707 booth, 716 booth, and 719 booth. The first sample was collected from the beginning of the shift until lunch time, while the second sample was collected from the time the employees returned from lunch until the end of the shift. Based upon a review of the MSDS for the paints in use on the day of the survey, samples collected in the breathing zones of the painter working at the 707 booth and the painter working at the 716 booth, were analyzed for xylene (all isomers) and naphtha. Samples were collected and analyzed in accordance with NIOSH Method 1501 for aromatic hydrocarbons and NIOSH Method 1550 for naphtha, with modifications.[1] The samples were collected on charcoal tubes in plastic holders connected via Tygon tubing to a battery-powered sampling pump operating at a flow rate of 100 mL/min. The LOD for xylene was 0.01 mg/sample, which resulted in a MDC of 0.08 ppm, based on the maximum sample volume of 28.8 L for this set of samples. The LOQ for xylene was 0.033 mg/sample, equal to an MQC of 0.26 ppm, based the maximum sample volume of 28.8 L. The MDC for naphtha was 3 mg/m^3, which was derived from the LOD of 0.1 mg/sample and the maximum sample volume of 28.8 L for this sample set. The LOQ for naphtha of 0.33 mg/sample resulted in a MQC of 11 mg/m^3, based upon the maximum sample volume of 28.8 L.

After reviewing the MSDSs for the paint and catalyst in use at the 719 booth, samples collected in the breathing zones of the two painters working there were analyzed for ethyl benzene, 1-methoxy-2-propanol, xylene (all isomers) and naphtha. Media standards prepared from a bulk sample of Catalyst 647 were used to quantitate naphtha. The samples were collected and analyzed according to NIOSH Methods 1403 and 1550 with modifications.[1] The samples were collected on charcoal tubes in plastic holders connected via Tygon tubing to a battery-powered sampling pump operating at a flow rate of 100 mL/min. The LOD for each

compound was 0.01 mg/sample. Based upon the maximum sample volume of 28.8 L, the MDCs were 0.08 ppm for xylene (all isomers) and ethyl benzene, 0.09 ppm for 1-methoxy-2-propanol, and 0.3 mg/m^3 for naphtha. The LOQ for each compound was
0.033 mg/sample, which equated to MQCs of 0.26 ppm for xylene (all isomers) and ethyl benzene, 0.31 ppm for 1-methoxy-2-propanol, and 1.1 mg/m^3 for naphtha. These values were derived from the maximum sample volume of 28.8 L for this set of samples.

Two consecutive partial-shift PBZ air samples for xylene (all isomers) and mineral spirits were collected in the breathing zone of the Young Brothers operator. The samples were collected and analyzed in accordance with NIOSH Methods 1501 and 1550 with modifications.[1] Samples were collected on charcoal tubes in a plastic holder clipped to the operator's lapel and connected via Tygon tubing to a battery-powered sampling pump at his waist. The samples were collected at a flow rate of 100 mL/min. The first sample was collected from the beginning of the shift until lunch time. The second sample represented the second half of the shift. Media standards prepared from a bulk sample of Sterling F-173 were used to quantitate mineral spirits. The LOD for both xylene and mineral spirits was 0.01 mg/sample. The LOQ for both compounds was 0.033 mg/sample. Based upon a maximum sample volume of 18.7 L, the MDCs were 0.1 ppm for xylene and 0.5 mg/m^3 for mineral spirits. The MQCs were 0.41 ppm for xylene and 1.8 mg/m^3 for mineral spirits. These values were derived from LOQs of 0.033 mg/sample and the maximum sample volume of 18.7 L for these samples.

Two consecutive partial-shift PBZ air samples for volatile organic compounds were collected in the breathing zone of the operator of the rotor cast machine to determine what emissions might be present due to the use of a die lubricant. Samples were collected on charcoal tubes in a plastic holder connected via Tygon tubing to a battery-operated sampling pump operating at a flow rate of 100 mL/min. The sample collected during the afternoon sampling period was submitted for qualitative analysis by gas chromatography-mass spectroscopy (GC-MS).[a]

Fifteen charcoal tube samples for volatile organic compounds were collected in department 707 and on the 180 line. The location of each of these samples is provided in Table 2. Of these 15 samples, 12 were partial-shift consecutive PBZ air samples, one was collected in the breathing zone of an employee who left at mid-morning, and

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[a.] Qualitative analysis tells the investigator what compounds are present in a sample. Quantitative analysis then indicates how much of a given compound is present.

two were full-shift area samples. The samples were collected on charcoal tubes in a plastic holder connected via Tygon tubing to a battery-operated sampling pump operating at a flow rate of 100 mL/min. The partial-shift samples represented the morning and afternoon periods of the work day. With the exception of the GA air samples, the pumps were turned off during the lunch period. The two PBZ air samples collected in the breathing zone of the 180 line painter were submitted for qualitative analysis by GC-MS. Based upon the results of the qualitative analysis, the remaining charcoal tubes and the charcoal tube sample collected during the morning in the breathing zone of the rotor cast operator were submitted for quantitative analysis using a combination of NIOSH Methods 1500 and 1501 for toluene, total xylenes, and C_8-C_9 hydrocarbons.[1] The LOD for both toluene and C_8-C_9 hydrocarbons (including xylene) was 0.9 µg/sample, which equates to a MDC of 0.006 ppm for toluene, and a MDC of 0.02 mg/m^3 for C_8-C_9 hydrocarbons (including xylene), based upon a maximum sample volume of 38.8 L for this sample set. The LOQ for toluene was 2.3 µg/sample, while the LOQ for
C_8-C_9 hydrocarbons (including xylene) was 2.9 µg/sample. These equate to MQCs of 0.016 ppm for toluene and 0.074 mg/m^3 for C_8-C_9 hydrocarbons (including xylene).

In addition to conducting air sampling, the NIOSH industrial hygienist reviewed records of air sampling conducted at the plant in the past, and interviewed a long-time employee about processes which were no longer in operation, focusing on those which may have exposed employees to known or suspected occupational carcinogens. Finally, because of employee concerns about the location of the replacement air intakes in relation to the exhaust ventilation stacks, the NIOSH investigator conducted a brief inspection of the roof of the plant.

. IV. EVALUATION CRITERIA

General guidelines

To assess the hazards posed by workplace exposures, NIOSH investigators use a variety of environmental evaluation criteria. These criteria suggest exposure levels which most workers may be exposed for a working lifetime without experiencing adverse health effects. However, because of wide variation in individual susceptibility, some workers may experience occupational illness even if exposures are maintained below these limits. The evaluation criteria do not take into account individual hypersensitivity, pre-existing medical conditions, or possible interactions with other work place agents, medications being taken by the worker, or environmental conditions.

Evaluation criteria for chemical substances are usually based on the average PBZ exposure to the airborne substance over an entire 8- to 10-hour workday, expressed as a time-weighted average (TWA). Personal exposures are usually expressed in ppm, mg/m^3, or µg/m^3. To supplement the 8-hr TWA where there are recognized adverse

effects from short-term exposures, some substances have a short-term exposure limit (STEL) for 15-minute peak periods; or a ceiling limit, which is not to be exceeded at any time. Additionally, some chemicals have a "skin" notation to indicate that the substance may be absorbed through direct contact of the material with the skin and mucous membranes.

The primary sources of evaluation criteria for the workplace are: NIOSH Criteria Documents and Recommended Exposure Limits (RELs), the Occupational Safety and Health Administration (OSHA) Permissible Exposure Limits (PELs), and the American Conference of Governmental Industrial Hygienists' (ACGIH) Threshold Limit Values (TLVs).[4,5,3] These criteria typically change over time as new information on the toxic effects of an agent become available.

The OSHA PELs reflect the economic feasibility of controlling exposures in various industries, public notice and comment, and judicial review; whereas the NIOSH RELs are based primarily on concerns related to the prevention of occupational disease. An additional complication is due to the fact that a Court of Appeals decision vacated the OSHA 1989 Air Contaminants Standard in *AFL-CIO v OSHA*, 965F.2d 962 (11th cir., 1992); OSHA is now enforcing the previous 1971 standards.[5] However, some states which have OSHA-approved State Plans will continue to enforce the more protective 1989 limits. NIOSH encourages employers to use the 1989 limits or the RELs, whichever are lower.

Formaldehyde

Formaldehyde is a colorless gas with a strong odor. Exposure to formaldehyde can occur through inhalation and skin absorption. The acute effects associated with formaldehyde are irritation of the eyes and respiratory tract and sensitization of the skin. The first symptoms associated with formaldehyde exposure, at concentrations ranging from 0.1 to 5 ppm, are burning of the eyes, tearing, and general irritation of the upper respiratory tract. Variations have been noted in individual tolerance and susceptibility to the effects of formaldehyde exposure.[6]

In two separate studies, formaldehyde has induced a rare form of nasal cancer in rodents. Formaldehyde exposure has been identified as a possible causative factor in cancer of the upper respiratory tract in a proportionate mortality study of workers in the garment industry.[7] NIOSH has identified formaldehyde as a suspected human carcinogen and recommends that exposures be reduced to the lowest feasible concentration. The OSHA PEL is 0.75 ppm as an 8-hour TWA and 2 ppm as a STEL.[8] ACGIH considers formaldehyde a suspected human carcinogen and therefore, recommends that worker exposure by all routes should be carefully controlled to levels "as low as reasonably achievable" below the TLV.[3] ACGIH has set a ceiling limit of 0.3 ppm.

Xylene

Xylene is a colorless, flammable organic liquid with a molecular structure consisting of a benzene ring with two methyl group (CH_3) substitutions. Xylene is used in paints and other coatings, as a raw material in the synthesis of organic chemicals, dyes, and pharmaceuticals. It is also an ingredient of gasoline (ranging from 1% to 10%) and many other petroleum solvents.[9] A NIOSH investigation of service station attendants found xylene content in gasoline ranging from 3.3% to 22%.[10]

The vapor of xylene has irritant effects on the skin and mucous membranes, including the eyes and respiratory tract. This irritation may cause itching, redness, inflammation, and discomfort. Repeated or prolonged skin contact may cause erythema, drying, and defatting which may lead to the formation of vesicles. At high concentrations, repeated exposure to xylene may cause reversible damage to the eyes.[11]

Acute xylene inhalation exposure may cause headache, dizziness, incoordination, drowsiness, and unconsciousness.[12] Previous studies have shown that concentrations from 60 to 350 ppm may cause giddiness, anorexia, and vomiting.[11] At high concentrations, exposure to xylene has a narcotic effect on the CNS, and minor reversible effects on the liver and kidneys.[11-13]

Historical accounts of hematopoietic toxicity as a result of xylene exposure are likely due to the high concentration of benzene contamination in xylene prior to 1940. These effects previously reported are no longer associated with contemporary xylene exposure.[12,14,15]

The current OSHA PEL, NIOSH REL, and ACGIH TLV for xylene are 100 ppm over an 8-hour TWA. In addition, OSHA and NIOSH have published STELs for xylene of 150 ppm averaged over 15 minutes.

Titanium Dioxide

Titanium dioxide is a mild pulmonary irritant and is generally considered to be a nuisance dust.[16] In the lungs of three workers working in titanium dioxide pigment processing, deposits of the dust resulted in findings that indicated that titanium dioxide is a minor pulmonary irritant. Rats repeatedly exposed to concentrations of 10 to 328 million particles/cubic ft of air for up to 13 months showed small focal areas of emphysema, attributable to large deposits of dust.[16] There was no evidence that titanium dioxide produced any specific lesion.

A two year inhalation bioassay by where rats were exposed to 250 mg/m^3 of titanium dioxide resulted in the development of squamous cell carcinomas in 13 of 74 female rats and in one of 77 male rats, as well as an increase in bronchoalveolar adenomas, another type of cancer. No excess tumor incidence was noted at 50 mg/m^3. The

authors of that study questioned the biologic relevance of these tumors to humans, given the extremely high exposure concentrations, the unusual histology and the location of the tumors, and the absence of metastases.[17]

The ACGIH TLV for titanium dioxide is 10 mg/m^3 as an 8-hour TWA.[3] The OSHA PEL is 15 mg/m^3 as an 8-hour TWA.[5] Based upon the animal inhalation study noted above, NIOSH considers titanium dioxide to be a potential occupational carcinogen and recommends that exposures be reduced to the lowest feasible concentration.[4,17]

IV. RESULTS

Medical

General Comments

A joint management-union safety committee provides training to workers four times a year. The annual training includes a recurring hazard communication briefing plus three other presentations which are selected based upon safety needs of the employees or recommendations of the safety committee.

Respiratory fit testing and training is conducted by the company nurse. Respirators were not issued based on exposure but by employee request. When the employee no longer desires to use the respirator they sign themselves out of the program. Disposable respirators are used and three months or more may pass before the respirator is replaced. Everyone on the respiratory protection program receives a chest x-ray and pulmonary function tests. Audiograms are conducted annually by a private contractor and fit testing is repeated every two years.

Employee Interviews

Confidential informal interviews were conducted with 43 workers, 36 of whom volunteered or specifically asked to meet with NIOSH representatives, and seven of whom were randomly selected. All employees interviewed had been employed by Reliance Electric for more than five years.

The most frequently reported symptoms were irritation of the eye, nose, and throat (51%) and headache (40%). Fifteen of 23 workers reporting irritant symptoms with fumes or odors from the white, black, and green paints and/or the Young Brothers oven emissions. The majority stated these symptoms resolved or improved when away work. Nine of the 17 workers who reported headaches associated their symptom with exposure to the Young Brothers oven emissions or white, black or green paint fumes. Ten of the employees interviewed expressed concern about the health effects of xylene exposure. The perceived excess of cancers among plant employees was the concern of 13 workers interviewed.

OSHA Form 200, Log and Summary of Occupational Injuries and Illnesses

The OSHA 200 logs for the period of 1990 through January 24, 1994 were reviewed. The 1992 log revealed three employees reported to have had bronchospasms as a result of a xylene spill at the plant. In addition, a number of back injuries and disorders attributable to repetitive trauma were noted on the OSHA 200 Logs. These injuries/disorders were found in both the injury and illness columns of the OSHA 200. Hand, wrist, elbow, and arm problems such as strains, parathesia, epicondylitis, tendinitis, and trigger finger were noted in the review and categorized as an upper extremity disorder for the purpose of this report. Table 3 describes the total number of injuries and illnesses, back injuries, and upper extremity disorders reported by year. Overall, 15 of 27 or 47% of repetitive motion disorders and eight of 19 or 47% of reported back injuries were recorded for occupational code 701, Winding, for the period January 1, 1990, through January 27, 1994. In 1993, upper extremity disorders accounted for 54% of all reported injuries and illnesses. Between 1990 and January 27, 1994, approximately 1,000 work days were lost as a result of upper extremity disorders.

Table 3.

Year	Total Injuries and Illnesses Reported	Back Injuries Number	Number of Reported Upper Extremity Disorders Number
1990	33	8	2
1991	23	3	5
1992	30	5	5
1993	26	3	14
1994, as of 27 Jan	6	--	1

Cancer Investigation

The original list of cancer cases was maintained over the years by a union officer, names were added, either by the ill individual or by word-of-mouth, and no action was taken to confirm or refute the diagnosis of cancer.

Table 4 provides information on the number and types of cancer cases which accompanied the original request and those verified as the result of a management review of available records (medical,personnel, and benefit). As a result of this review five additional cases, not on the original union list, were added and 37 suspected cases were not verified for one of the following reasons: (a) There was no company record confirming the diagnosis (18); (b) Company records indicated medical leave or death from other causes; (4), (c) No medical record or death benefits information (9); (d) No record existed indicating they ever worked for the company (3); or (e) Personnel records indicate that workers left Reliance for other than medical reasons (3); Finally, Table 4 also indicates the number of workers employed at least ten years prior to diagnosis of cancer.

Table 4.

Comparison of Suspected Cancers Cases with Verified Cancer Cases by Type			
Breast	12	7	7
Lung	9	4	4
Alimentary Canal	5	6	6
Pancreas	8	4	4
Reproductive (Female)	7	6	3
Skin	8	2	2
Melanoma	1	4	4
Thyroid	1	1	1
Hodgkins	2	1	1
Prostate	2	1	1
Leukemia	4	0	0
Oral	3	3	2
Kidney	2	1	1
Lymphoma	1	2	2
Unspecified	11	0	0
Reproductive (Male)	--	1	0
Bone	--	1	1
Parathyroid	--	1	0
TOTAL:	77	45	39

A review of the cancer data for the 39 workers employed at least ten years prior to diagnosis, medical leave or retirement/termination, indicated that the years of seniority at these time ranged from 10.1 to 40 years. Additionally, the age of the individuals at the same time ranged from 29.7 to 66 years of age. Fifty-four percent of the cases were women and 46% men.

Originally there was thought to be eight pancreatic cancers among Reliance workers. As a result of company record's review four were removed from analysis for the following reasons: 1) No medical or benefit records available on three, and 2) One individual was diagnosed with cancer of the esophagus not pancreas. Company records indicated that these individuals had worked for two to seven years at Reliance. The original union list did not have date of diagnosis or death on these employees either. Additionally, company records did not indicated that these individuals left Reliance for medical reasons but three workers left as a result of employee (2) and plant termination of employment (1).

Four cases of pancreatic cancer were confirmed as a result of company and death certificate review. Length of employment at Reliance for these individuals was 13 to 25 years, mean of 20.25 years. Age range at time of death for three of the individuals was 57 to 70 years and age

individuals showed that three of four had worked at some time during their tenure at Reliance in the same occupational code (701).

Industrial Hygiene

The results of the analysis of the GA air samples for formaldehyde are presented in Table 6. Eight hour TWA concentrations, calculated assuming zero exposure for the unsampled period, ranged from a trace concentration measured outside the building to 0.017 ppm measured in a sample collected on the table by the scratch brush in the winding area. A trace concentration is a value between the LOD and the LOQ and should be regarded with limited confidence in its accuracy. While the results of the area samples are well below the occupational exposure criteria for formaldehyde established by OSHA and the ACGIH, the fact that the concentrations measured inside the plant exceeded the trace concentration measured outside the plant indicate that a further reduction is both necessary and feasible in order to reach the NIOSH REL for formaldehyde of lowest feasible limit. Analysis of the GA air samples collected for total particulate in the same locations as the GA air samples for formaldehyde revealed total particulate concentrations less than the LOD of the method. These results indicate that the local exhaust ventilation systems in place at the two scratch brush operations are effective in controlling particulate emissions. On the day of the survey, the scratch brush operator in the winding area ground a total of 45 windings. Analysis of the PBZ air samples for formaldehyde collected in the breathing zones of the Young Brothers operator and the operator of the scratch brush in the winding area revealed only trace concentrations of formaldehyde. The Young Brothers operator stated that sampling represented a typical day. The results of the PBZ air samples for formaldehyde on dust collected in the breathing zones of the same employees were less than the LOD of the method.

Table 7 provides the results of PBZ air sampling for metals. The results are all less than the occupational exposure criteria for the various metals with the exception of titanium dioxide (measured here as titanium), which NIOSH considers to be a potential occupational carcinogen.[4] While the measured concentrations are very low, they exceed the NIOSH REL of LFL for titanium dioxide. The results also indicate that although the MSDS, provided by the company for the Non-Toxic Blue-Green paint stated that the paint contained nickel, that MSDS was outdated, as the NIOSH investigators learned by calling the paint manufacturer. In the case of some of the metals in Table 7 listed as having no occupational exposure criteria, there are exposure criteria for the oxides of these metals. Those criteria apply to operations where metal oxide fumes are generated or where metal oxides are used to compound material, such as the use of titanium dioxide as an ingredient in paints. Metal oxide fumes are generated where metal is heated to a point where metal vapors are generated, which then condense to form metal oxide fumes. While this might occur during the rotor casting operation, it would not occur during painting of motor components.

The results of air sampling for xylene and naphtha in the breathing zone of the painters in department 716 and department 707 are given in Table 8. These results were well below the applicable evaluation criteria for xylene and naphtha. Table 9 provides the results of air sampling performed to assess employee exposures to xylene, naphtha, ethyl benzene, and 1-methoxy-2-propanol. Like the results for the other spray painters, the air samples indicated that exposures to these compounds were well below the relevant occupational exposure

criteria. All of these results indicate that the work practices of the painters act in combination with effective local exhaust ventilation to control the painters' exposures.

The PBZ samples collected to assess the Young Brothers operator's exposure to xylene and mineral spirits revealed 8-hour TWA exposures of 11.1 ppm for xylene and 17.5 mg/m^3 for mineral spirits. On the day that samples were collected, this employee performed hand dipping as well as operating the Young Brothers machine. These results were also well below the occupational exposure criteria for xylene and mineral spirits. The results of the charcoal tube sample collected in the afternoon in the breathing zone of the rotor cast operator and submitted for qualitative analysis had no detectable peaks. The results of the other two charcoal tubes collected in the breathing zone of the 180 line painter and submitted for qualitative analysis are provided as reconstructed total ion chromatograms with identified peaks labelled in Figures 1 and 2. The major component on each tube was xylene. Other compounds detected were toluene, C_8-C_9 alkanes, and hexane.

The results of the quantitative analysis of the charcoal tube sample collected in the morning in the breathing zone of the rotorcast operator and the charcoal tube samples collected in Department 707 and on the 180 line are presented in Table 2. The results for toluene and C_8-C_9 hydrocarbons, including xylene, were all very low in relation to the evaluation criteria for these compounds, again indicating that exposures to these compounds do not pose a hazard to the employees working in those areas.

The request specifically mentioned several compounds, including a beryllium aluminum alloy, zinc chromate primer, polyamide PK-4. The use of all of these products had stopped prior to the NIOSH investigation. Other process changes included the elimination three years ago of a salt bath used to harden shafts, the removal of four die cast machines that had been used to cast aluminum end shields, the removal of an annealing furnace, a reduction in the number of end shields turned in the machining process, and the elimination many years ago of the use of a red lead primer. Hexachloroethane was used as an additive in aluminum melts, but its use was eliminated when casting was discontinued.

Review of air sampling records provided by the company revealed exposures at concentrations similar to the ones documented by the NIOSH industrial hygienist. A sample collected in 1987 to assess exposure to hexachloroethane found none. A sample collected while a welder welded nipples on an explosion proof motor revealed a concentration of nickel of 0.0256 mg/m^3 for a 125 minute sample. This result exceeded the NIOSH REL for nickel of 0.015 mg/m^3, only if the exposure resulting from that activity continued at the measured concentration for the rest of the day.

Tempered replacement air is provided to the plant through units mounted in the walls of the plant and distributed through cloth ducts, which the employees refer to as blue bags. Employees complain that the blue bags bring in odors from outside the plant. A tour of the roof revealed that many of the exhaust stacks are relatively low in relation to the height of the

building. A combination of low stacks and wall-mounted replacement air units is an example of poor system design and has been shown to be prone to the reentrainment of stack emissions, as shown in Figure 3.[18]

Finally, during the course of the investigation employees complained to the NIOSH investigators about odors emanating from an oven in which aluminum finned motors are heated. While the oven is ventilated, the effectiveness of the ventilation should be assessed in light of employee complaints.

VI. DISCUSSION AND CONCLUSIONS

Cancer

Cancer is a group of diseases that share a common feature, the uncontrolled growth and spread of abnormal cells. Cancer is common in the United States. About one in three people will eventually develop cancer. One of every five deaths is from cancer. Among adults, cancer occurs more frequently among men than women, and the rate of occurrence increases with age.[19]

Cancer is a common disease thus it is predicted that some workers will develop cancer. As a work population ages, workers may sense that there are a greater number of cancers as their friends and family, of similar age, develop disease.

Some of the causes of cancer are known; these include many different factors involving lifestyle, work, the environment, and heredity. Table 9 describes non-occupational cancer-causing exposures. For many types of cancer, however, the causes, remain unknown.[19]

Table 9.

Non-Occupational Causes of Cancer ([d])

Cause	Cancers
Smoking	Lung, mouth, esophagus, pancreas, larynx, liver, bladder, kidney
Sunlight	Skin (melanoma & non-melanoma)
Heavy alcohol use	Mouth, larynx, throat, esophagus, liver
Diets high in fat	Colon, rectum, breast, prostate
Reproductive history	Breast, cervical, ovary

Cancers often appear in clusters. Cases that are close together in time or space may have a common cause or may be the coincidental occurrence of unrelated causes. The number of cases may seem high, particularly among a small group people who have something in common with the cases, such as working in the same building.

[d.] Abstracted from the New Jersey State Department of Health, Occupational Cancer and the Investigation of Reported Cancer Clusters at Work. May, 1991.

A cancer cluster is defined as an unusual concentration of cancer cases. The hallmark of a cancer cluster is a high number of cases of one or more specific types of cancer in a specific population during a certain time period. A cancer cluster may also consist of an unusual distribution of types of cancer, ages of cases, or sex.

Historically, cancer cluster investigations have provided clues to the causes of certain cancers. Most cluster investigations, however, have not been productive in furthering knowledge about the causes of cancer.

Since cancer is the second leading cause of death in the United States, determining whether exposures at a workplace are causally related to a cancer "cluster" can be difficult, especially when the types of cancer are multiple, the number of each type of cancer is few, the population defined to be "at risk" (e.g., exposed workers) is relatively smal,l[20], and the period between the exposure to the suspected causal factor and the diagnosis is relatively short.

Over the years NIOSH has received many requests for assistance from people who are concerned about an apparent excess of cancer among employees in their workplaces. Several elements are required to establish that cancers that occur among employees are work-related. These elements include: (a) Establishing that the number of cancer cases is greater than would be expected in a similar population during the same time period; (b) Verifying that there is an unusual distribution of types of cancer or of the age or gender of the persons with cancer; (c)

Determining whether the cancers have occurred about 15 to 20 years after first exposure or first employment in a building (typically, cancers of occupational origin require about 15 to 20 years to develop from the time of first exposure to the causative agent to clinical detection); and (d) Identifying a potential factor, such as exposure to a specific chemical or physical agents known or suspected of causing cancer.[21,22]

To determine if there was an unusual distribution of cancer types, or of the age or gender of the persons with cancer, analysis of the cancer data was accomplished. Fifty-four percent of all verified cancers occurred in female employees, of these nine cases were breast or reproductive cancers for which there are no known occupational exposures. The age range was 29.7 to 66 years. Fifty-four percent of the cases were diagnoses in women and 46% in men. The age- and sex-distribution of the 39 verified cancer in individuals with ten years of more employment does not appear unusual.

Using a conservative estimate of cancer latency of ten years, the following was determined. A review of the cancer data for the 39 workers, employed at least ten years prior to diagnoses, indicated that the years of seniority at time of medical leave, diagnosis or death, ranged from less than 10.1 to 40 years with a mean of 21.3 years. Further analysis was undertaken to determine whether or not there was an unusual distribution of cancer types.

To analyze whether or not there was an unusual distribution of the types of cancer at Reliance, a crude standardized incidence rate based on estimated cancer incidence rates[19] in Indiana, and using U.S. census data,[23] were calculated for cancers with four or more cases as seen in Table III. The following assumptions were made for this analysis: 1) that the average population of Reliance was 450 persons over it's 20 years (1975 - 1994) of operation during which the 39 verified cases were reported, and 2) that Indiana incidence rates were applicable to this population. Age- or sex- (other than breast cancer) adjusted incidence rates were not calculated. Additionally, all cancer cases, whether a survivor or not, were used to determine the incidence rates. Table 10 shows the results of this analysis. A discussion on each type of cancer located either in the footnotes, or after the table.

Table 10.

Standardized Incidence Rate for Reliance employees			
Type of Cancer	**Expected**	**Observed**	Standardized Incidence Rate ([e]) **(Observed/Expected)**
Breast	6.83	7	1.02
Melanoma	.953	4	4.19
Pancreas	.874	4	4.575
Lung	6.67	4	.599
Alimentary Canal	5.4	6	1.11

Breast cancer is the most common cancer among women in the U.S., occurring in about one of every nine women. Risk factors include, but are not limited, to, being over age 40, and increases with age and familial history of breast cancer.[19] Generally, breast cancer is not known to have any association with environmental or occupational exposures other than ionizing radiation.[24]

[e.] Estimated incidence rates are based on the most current (1987-89) data available from the Surveillance, Epidemiology and End Results (SEER) Program, Division of Cancer Prevention and Control.

Although epidemiologic studies have identified some factors that appear to be related to increased risk for breast cancer, much remains unknown about the causes of breast cancer. Recently, there have been some reports about a possible relationship between breast cancer and exposure to specific types of chemicals, including certain pesticides.[25] Although there is preliminary evidence to suggest that exposure to these chemicals in the general environmental (for example, through food sources) may play a role in the development of breast cancer, further studies are needed to establish a clear link. Based on the expected number of breast cancer in the Reliance population there is no statistically significant increase in the observed cases.

Melanoma is a serious type of skin cancer. People with lightly pigmented skin are more likely to develop this type of cancer. Caucasians are more than ten times more likely to develop this disease than blacks.[19] Occupational exposure to coal tar, pitch, creosote, arsenic compounds, or radium are associated with development of pancreatic cancer.[19] A strong risk factor for developing melanoma is early intermittent ultraviolet radiation exposure; in particular, exposure resulting from severe sunburns in childhood. Family history of dysplastic nevi is also an attributable risk factor of melanoma.[26] The number of melanomas verified in the plant were three times more than expected. None of the occupational exposures associated with melanoma are currently used at Reliance. No information was available about race or past ultraviolet radiation exposure of these individuals.

The four cases of pancreatic cancer is four times what was expected in this population. Little is known about cancer of the pancreas. The disease is diagnosed more frequently in men than women. Cases under the age of 30 are unusual; most occur after age 50.[19,24] The age range for individuals diagnosed at Reliance was 47 to 70. Three of the four were over 50.

Occupational work histories for these four individuals showed that three of the four had worked at some time during their tenure at Reliance in the same occupational code (OC)(701). Length of employment in OC 701 ranged from two to 20 years. No specific job was held by the three employees.

An association with chronic pancreatitis, diabetes or cirrhosis has been proposed but not confirmed.[27] One study showed that men and women whose diets were high in fat were greater risk of developing pancreatic cancer.[28] Slight excesses of pancreatic cancer have been identified in certain occupational groups such as rubber and wood/paper workers.[29] The literature review did not identify any known exposures at Reliance associated with pancreatic cancer.

Twenty-two percent of all cancers diagnosed in men are of the lung.[30] As of 1993, lung cancer causes more deaths in women than breast cancer. Some of the risk factors for lung cancer are well known, e.g., cigarette smoking, asbestos exposure. Nonsmokers are also felt to be at risk

as a result of exposure to sidestream cigarette smoking.[19] The number of lung cancer cases identified at Reliance was not statistically significant.

In the United States the American Cancer Society predicted there would be 109,000 new colon cancer cases diagnosed in 1993. Cancer of the colon and rectum is the third most common cause of cancer deaths in both men and women. A family history, high-fat and/or low carbohydrate diets and certain types of bowel disorders appear to place certain individuals at greater risk for disease. Other than asbestos exposure there are no identified occupational exposures which increase an individuals risk for developing colon and rectum cancer.[19,24]

To evaluate further the concern of these 39 verified cases of cancer representing a cancer cluster the following points were address. When a cancer cluster is identified among a group of workers, several questions are studied to determine if the cluster could be related to occupational exposures. Among these questions are: 1) Have other studies found an association between the potential exposure or work setting under investigation and the types of cancer in the cancer cluster?; 2) Are the workers with cancer concentrated in a particular job title or location?; and 3) Are there non-occupational causes for the types of cancer in the cluster?

Most cancer-causing substances are known to cause only one or two different types of cancer. The reported cancer cluster at Reliance Electric included multiple types of cancers, a small

number of each type of cancer diagnosed, and a relatively small "at risk" population. All of these are unfavorable conditions for documenting an association between the cancers and a work-place exposure.

Evaluation as to whether or not there was a concentration of cancer in a particular work area was accomplished. Overall, including the melanoma cases (based on last known occupational code), the verified cancers occurred among management and plant workers and were not concentrated in particular occupational code. Of the four cases of pancreatic cancer, as mentioned previously, three had worked in the occupational code, 701 for varying lengths of time.

Other than the pancreas cancers and melanomas, the distribution of types of cancer cases reported among Reliance employees is not unusual. Neither the distribution of cancer types nor the demographic characteristics (i.e., age, sex, race) of the persons with cancer does not appear to be unusual. Breast, and skin cancer such as melanoma are among the most common types of cancer in the U.S. population.

The exposures (e.g., titanium oxide, formaldehyde, and nickel) identified by NIOSH investigators are not associated with cancer of the pancreas or melanoma. Based on the lack of evidence of medically significant exposures to chemical or physical agents, it is unlikely that the cases of cancer can be attributed to the environment of Reliance Electric.

Reported Symptoms

Eye, nose, and throat (e.g., cough and sore throat) irritation, were reported by workers interviewed. These symptoms were consistent with health effects which could be related exposures found at Reliance such as formaldehyde, tobacco smoke, and xylene.

Central nervous system symptoms reported by employees such as headaches, tiredness, dizziness, and one who reported change in mood and personality are consistent with health effects related to inhalation exposure to formaldehyde.

Musculoskeletal Findings

Repetitive, forceful motions or awkward positions of the hand, wrist, arm, and/or shoulder in the performance of job tasks are associated with cumulative trauma disorders. The predominance of the reported repetitive motion disorders occurred in the Winding occupational center. Activities accomplished in this occupational center were not evaluated. Evaluation of and preventive measures should be undertaken to decrease the risk of developing cumulative trauma disorders among workers.

Conclusions

With the exception of exposure to formaldehyde and titanium dioxide above their NIOSH RELs of LFL, the NIOSH industrial hygiene sampling did not reveal any overexposures to any of the compounds sampled. The walkthrough tour of the plant revealed some deficiencies in

the ventilation system. The outdated MSDS the company had on hand for the Non-Toxic Blue-Green paint revealed a problem with the hazard communication program. In light of the nickel exposure documented by the company, the effectiveness of the local exhaust ventilation used when welding nickel-containing allows should be assessed. Recommendations to deal with these issues are provided in Section VIII.

It should be noted that after the NIOSH visit in December 1993 a number of recommendations were instituted by Reliance Electric. Corrective actions such as the stack in the rotocast area was changed; paint residue was removed; the old respirators were disposed of; and management met unsuccessfully with the local union regarding Reliance becoming a tobacco-free workplace.

VII. **Recommendations**

1. A more active role by medical personnel to identify and investigate spected or unusual disease clusters and health concerns occurring among workers and management should work with the safety committee to provide information concerns regarding these to employees is recommended.

2. The majority of the employees at Reliance are in the age range in which the American Cancer Society recommends routine screening for certain types of cancer. Enclosed for their information is a copy of the summary of 1993 ACS

recommendations for cancer screening taken from CA-A Cancer Journal for Clinicians, January/February 1993, volume 43, number 1.

3. It is recommended that medical personnel provide literature or training on skin cancer prevention to workers.

4. A program for the prevention of cumulative trauma disorders should be developed. Such a program should include the following[31]:

a. Worksite analysis to recognize and identify ergonomic hazards.

b. Hazard prevention and control, to include:

(1) Selection of tools and handles designed to eliminate or minimize chronic muscle contraction or steady force, extreme or awkward finger/hand/arm positions, repetitive forceful motions, and excessive gripping pinching, and pressing with the hand and fingers.

(2) Work practice controls

(3) Administrative controls

c. Medical management, to include recordkeeping, early recognition and reporting, systematic evaluation and referral, conservative treatment, conservative return to work, and systematic monitoring.

d. Training and education for employees, supervisors, managers, and health care providers.

5. Occupational medical examination requirements should appropriate for the exposure. These examinations requirements should be evaluated periodically.

6. NIOSH investigators observed several respirators stored in a paint locker near the paint booth in Department 719. The respirators were dirty and were lying on a shelf in the cabinet. Respirators should be regularly cleaned and disinfected, and should be stored in a convenient, clean, and sanitary location.[32] The respirators in the paint locker should be cleaned (or discarded and replaced), and stored in a sanitary container, such as a plastic bag. Ziploc™-type bags, drawstring bags, and bags secured with twist -ties are often used for this purpose.

7. Although a respiratory protection program is in place, certain elements, (e.g., respirator storage, examine requirements, employee training) were deficient; thus, if respirator use is necessary, implement a Respiratory Protection Program that provides medical

surveillance and fit-testing for employees who use respirators, in accordance with the requirements described in 29 CFR 1910.134.[32] Publications developed by NIOSH which should also be referenced when developing an effective respirator program, include NIOSH Respirator Decision Logic and the NIOSH Guide to Industrial Respiratory Protection.[33,34]

8. The automated paint booth near the booth, described above, contained accumulations of paint residue. Spraying areas should be kept as free from the accumulation of deposits of combustible residues as possible, with cleaning conducted daily if necessary. Scrapers and other such tools used for cleaning should be made of non-sparking material.[35]

9. The NIOSH investigators observed several employees smoking on the plant floor. NIOSH recommends that workers should not be involuntarily exposed to tobacco smoke.[36] Exposure to environmental tobacco smoke (ETS) may be responsible for irritant symptoms and can exacerbate allergic symptoms. Further, NIOSH has determined that ETS poses an increased risk of lung cancer and possibly heart disease to occupationally exposed workers.[36] The best method for controlling worker exposure to ETS is to eliminate tobacco use from the workplace and to implement a smoking cessation program. Until tobacco use can be completely eliminated, the employer should make efforts to protect nonsmokers from ETS by isolating areas where smoking is permitted. Restricting smoking to smoking areas outside the building (away from entrances, air intakes, and operable windows) or in

separate smoking areas with dedicated ventilation are two ways to this. Air from smoking areas should be exhausted directly outside and not recirculated within the building or mixed with the general dilution ventilation for the building. The American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) recommends 60 cubic feet per minute (cfm) per person of outside, or transfer air, be supplied to the smoking area. A negative pressure should be provided to prevent airflow back into the non-smoking workplace.[36,37]

10. During the walk-through tour, an employee expressed concern about lead exposures and the "smog hog" device used to filter and recirculate air from a soldering operation. While soldering with a gun or iron typically occurs at temperatures too low to generate a significant concentration of lead fume, the OSHA lead standard requires that the employer assure that the system has a high efficiency filter with a reliable back-up filter; and controls to monitor the concentration of lead in the return air and bypass the recirculation system automatically if it fails.[38,39] The "smog hog" should be evaluated to ensure that it satisfies these requirements.

11. The exhaust ventilation system on the rotor cast machine consists of a fan and a short length of duct on the top of the machine, and a roof exhauster well above the end of this duct. Replacement air is provided to the area. While the replacement air is an excellent design feature, the four-cavity die cast machine could be better exhausted if the duct ran

from the machine to the exterior of the roof, thus carrying emissions out of the plant. In addition, the fan should be installed at the exhaust end of the duct. The duct would then be under a negative pressure, ensuring that any leakage in the duct would cause air to move to the duct, rather than into the facility. Consult a ventilation reference such as the latest edition of Industrial Ventilation for guidance.[18]

12. The concentration of formaldehyde measured in the area samples collected inside the plant may be reduced in several ways. A varnish which does not release formaldehyde during the curing process might be substituted for the Isonel 32-RF varnish now in use. If this is not feasible, the effectiveness of local exhaust ventilation on the Young Brothers machine and around the hand-dip tanks might be improved. Finally, additional tempered replacement air could be introduced into the areas where the varnish cures to dilute the concentration of formaldehyde to acceptable levels. The concentration of titanium dioxide measured in the PBZ samples collected during spray painting at the booths in Departments 707 and 719 could be reduced by following an analogous series of steps.

13. As a result of the problem encountered with the MSDS for the Non-Toxic Blue-Green paint, the hazard communication program should be reviewed to ensure that all of the MSDSs on hand reflect current product formulations. The procedure to update MSDSs should be reviewed to ensure that it is adequate.

14. Local exhaust ventilation used when welding nipples on explosion proof motors should be assessed to ensure that it is adequate to control employee exposure to nickel, and that the system is used in accordance with its design.

15. The height of building discharge stacks should be raised. Current guidelines indicate that the stack height plus building height equal to 1.3 to 2.0 times the height of the building is preferred, and that low discharge stacks relative to building height and air inlets should be avoided.[40]

16. The exhaust ventilation in place on the oven used to heat aluminum-finned motors should be assessed to ensure that it is performing to its design values and that the design is adequate. The ventilation should create a negative pressure sufficient to capture emissions that are released when the oven door is opened to remove parts. It may be necessary to provide supplemental ventilation to remove contaminants released as the parts cool.

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Table 1
Analytical Limits for Analysis of Metals
Reliance Electric Company
Madison, Indiana
February 22, 1994
HETA 93-1084

Analyte (elemental symbol)	LOD µg/filter	LOQ µg/filter	MDC mg/m^3	MQC mg/m^3
Aluminum (Al)	2	5.6	0.003	0.0071
Arsenic (As)	3	8.2	0.004	0.010
Barium (Ba)	0.08	0.25	0.0001	0.00032
Beryllium (Be)	0.04	0.12	0.00005	0.00015
Cadmium (Cd)	0.2	0.35	0.0003	0.00044
Cobalt (Co)	0.4	1.2	0.0005	0.0015
Chromium (Cr)	3	7.0	0.004	0.0089
Copper (Cu)	0.4	1.1	0.0005	0.0014
Iron (Fe)	2	6.5	0.003	0.0082
Lithium (Li)	0.2	0.42	0.0003	0.00053
Magnesium (Mg)	2	4.6	0.003	0.0058
Manganese (Mn)	0.09	0.29	0.0001	0.00037
Molybdenum (Mo)	0.2	0.35	0.0003	0.00044
Nickel (Ni)	0.8	2.7	0.001	0.0034
Lead (Pb)	2	4.0	0.003	0.0051
Phosphorous (P)	4	13	0.005	0.016

Platinum (Pt)	3	7.7	0.004	0.0097
Selenium (Se)	3	8.9	0.004	0.011
Silver (Ag)	0.09	0.28	0.0001	0.00035
Tellurium (Te)	2	6.4	0.003	0.0081
Thallium (Tl)	3	9.4	0.004	0.012
Titanium (Ti)	0.2	0.61	0.0003	0.00077
Vanadium (V)	0.4	1.3	0.0005	0.0016
Yttrium (Y)	0.07	0.21	0.0001	0.00027
Zinc (Zn)	0.9	2.9	0.001	0.0037
Zirconium (Zr)	0.2	0.66	0.0003	0.00084

Notes: LOD means limit of detection. LOQ means limit of quantitation. MDC is the minimum detectable concentration, based upon the LOD and a maximum sample volume of 790 liters for this sample set. MQC is the minimum quantifiable concentration, derived from the LOQ and the 790 liter sample volume. µg means micrograms. mg/m^3 is the abbreviation for milligrams of analyte per cubic meter of sampled air.

Table 2: Results of Quantitative Analysis of Air Samples for Toluene and C_8-C_9 Hydrocarbons*, Department 707, 180 Line, and Rotorcast, Reliance Electric Company, Madison, Indiana, February 22, 1994, HETA 93-1084

Job Title or Activity	Sample Duration (minutes)		Sample Volume (liters)		8-hour Time Weighted Average Results	
	a.m.	p.m.	a.m.	p.m.	Toluene (ppm)	C_8-C_9 Hydrocarbons (mg/m^3)*
Assemble Motors, Dept 707, Line 1, Station 2	247	108	24.7	10.8	<0.02	2.1
Running Bearing Press, Dept 707, Near 180 Line	253	113	25.3	11.3	<0.02	3.2
Assemble Motors, Dept 707, Line 2, Station 3	249	111	24.9	11.1	<0.03	3.5
Assemble Motors, Dept 707, Line 3, 1st Bench, Station 1	238	112	23.8	11.2	<0.02	3.3
Assemble Motors, Dept 707, Line 5, Station 1	245	112	24.5	11.2	0.04	3.4
Painter, 180 Line**	186	---	18.6	---	0.02	5.4
Rotorcast Operator***	287	---	28.7	---	0.02	0.41
Area Sample, Assembler, 180 Line	385	****	38.5	****	trace	4.0
Area Sample, Tester, 180 Line	388	****	38.8	****	trace	5.0
NIOSH Recommended Exposure Limit					100 TWA, 150 STEL	435 TWA, 655 STEL
OSHA Permissible Exposure Limit					200 TWA, 300 Ceiling, 500 Peak, for 10 min/8hrs	435 TWA

ACGIH Threshold Limit Value	50 TWA (skin)	434 TWA 651 STEL

Notes: 8-hour time weighted average (TWA) exposures were calculated assuming no exposure occurred during the unsampled portion of the shift. ppm is parts per million. mg/m^3 is milligrams of analyte per cubic meter of sampled air. C_8-C_9 hydrocarbons are expressed as mg/m^3 because these are a mixture of hyrocarbons, STEL is a short term exposure limit. C indicates a ceiling limit, one which should not be exceeded during any part of the work day. A trace value is one which lies between the minimum detectable concentration and the minimum quantfiable concentration, of limited accuracy. * including xylene. ** Employee left at 10:30 a.m. *** Results for a.m. sample only, the sample collected in the p.m. was submitted for qualitative analysis. **** The area samples were full-shift samples. < Indicates that the afternoon samples contained no toluene. The MDC and MQC for toluene were 0.006 ppm and 0.016 ppm, respectively, based upon a maximum sample volume of 38.8 liters. The MDC and MQC for C_8-C_9 hydrocarbons were 0.02 mg/m^3 and 0.074 mg/m^3, respectively, based upon the same maximum sample volume. The evaluation criteria provided in the rightmost column are for xylene, since xylene was included in this mixture.

Table 5
Results of General Area Samples for Formaldehyde
Reliance Electric Company
Madison, Indiana
February 22, 1994
HETA 93-1084

Location	Sample Duration (minutes)	Sample Volume (liters)	Results (ppm formaldehyde)	8-Hour TWA results (ppm formaldehyde)
Table by Scratch Brush, Winding Area	347	330	0.023	0.017
Top of Scratch Brush by Young Brothers Machine	343	343	0.016	0.011
On Desk by Hand Dip Varnish Tanks	341	324	0.019	0.013
Outside Building	338	338	trace	trace

Notes: ppm means parts per million. 8-hour TWA means the 8-hour time weighted average concentration of formaldehyde. Trace means the results were between the minimum detectable concentration (MDC) and the minimum quantifiable concentration (MQC). The MDC for these samples was 0.0007 ppm, based upon the maximum sample volume of 343 liters (L) for this set of samples. The MQC for these samples was 0.002 ppm, based upon a maximum sample volume of 343 L. NIOSH recommends that formaldehyde concentrations be reduced to the lowest feasible level. The OSHA Permissible Exposure Limit for formaldehyde is 0.75 ppm as an 8-hour TWA. The ACGIH Threshold Limit Value for formaldehyde is 0.3 ppm as a ceiling limit. A ceiling limit is a concentration which should not be exceeded during any part of the working exposure.

Table 6
Results of Personal Breathing Zone Air Samples for Metals
Reliance Electric Company
Madison, Indiana
February 22, 1994
HETA 93-1084

Job Title or Activity	Sample Duration (minutes)	Sample Volume (liters)	8-Hour Time Weighted Average Results (mg/m^3)								
			Al	**Ba**	**Fe**	**Mg**	**Mn**	**Mo**	**Ti**	**Zn**	**Zr**
Rotor Cast Operator	395	790	ND	ND	trace	ND	trace	ND	ND	ND	ND
Spray Painter, 707 Booth	338	676	ND	trace	trace	0.007	trace	trace	0.0007	0.01	ND
Spray Painter, 719 Booth	383	766	ND	ND	0.007	ND	trace	ND	ND	trace	ND
Spray Painter, 719 Booth	386	772	trace	trace	trace	ND	trace	ND	0.003	ND	0.001
Spray Painter, 716 Booth	395	790	ND	ND	trace	ND	trace	ND	trace	ND	ND
NIOSH Recommended Exposure Limit			10	0.5	5	none†	1 TWA, 3 STEL	none	LFL	none†	5 TWA, 10 STEL
OSHA Permissible Exposure Limit			15	0.5	none*	none†	5 Ceiling	15	15	none‹	5
ACGIH Threshold Limit Value			10	0.5	none*	none†	5	10	10	none‹	5 TWA, 10 STEL

Notes: mg/m^3 means milligrams of analyte per cubic meter of sampled air. ND (not detected) indicates a concentration less than the minimum quantifiable concentration. The TWA concentration was calculated assuming that no further exposure occurred during the unsampled period. Trace indicates a value between the minium detectable concentration and the minimum quantifiable concentration and should be regarded with limited confidence in its accuracy. STEL means short term exposure limit. A ceiling limit is one which

should not be exceeded during any part of the work day. None indicates that there is no occupational exposure criterion, or that the established criterion applies to the metal oxide fume, which was not believed to be applicable to the painting processes sampled. * The OSHA PEL of 10 mg/m^3 and the ACGIH TLV of 5 mg/m^3 for iron oxide fume would apply to the rotor cast operation. ‹Although the evaluation criteria for metal oxides would apply to the rotor cast operation, the criteria are not listed since these metals were not detected in the rotor cast samples.

Table 7
Results of Personal Breathing Zone Air Samples for Xylene and Naphtha
Spray Painters, Departments 716 and 707
Reliance Electric Company
Madison, Indiana
February 22, 1994
HETA 93-1084

Job Title or Activity	Sample Duration (minutes)		Sample Volume (liters)		8-hour Time Weighted Average Results	
	a.m.	p.m.	a.m.	p.m.	Xylene (ppm)	Naphtha (mg/m^3)
Spray Painter, 716 Booth	288	107	28.8	10.7	<0.5	trace
Spray Painter, 707 Booth	230	116	23.0	11.6	1	trace
NIOSH Recommended Exposure Limit					100 TWA, 150 STEL	350 TWA, 1800 C
OSHA Permissible Exposure Limit					100 TWA	2000 TWA
ACGIH Threshold Limit Value					100 TWA, 150 STEL	1370 TWA

Notes: Eight-hour time weighted average (TWA) exposures were calculated assuming that no exposure occurred during the unsampled portion of the shift. ppm means parts per million. mg/m^3 means milligrams of analyte per cubic meter of sampled air. Values for naphtha are expressed as mg/m^3 because naphtha is a mixture of hyrocarbons, while xylene is a compound with a defined formula, and thus a specific molecular weight. Molecular weight must be known to calculate ppm. STEL is a short term exposure limit. C indicates a ceiling limit, one which should not be exceeded during any part of the work day. A trace value is one which lies between the minimum detectable concentration and the minimum quantfiable concentration, of limited accuracy. < indicates that the results of the afternon sample used to compute the TWA was a trace value.

Table 8
Results of Personal Breathing Zone Air Samples for Xylene, Naphtha, Ethyl Benzene, and 1-Methoxy-2-Propanol
Spray Painters, Department 719
Reliance Electric Company
Madison, Indiana
February 22, 1994
HETA 93-1084

Job Title or Activity	Sample Duration (minutes)		Sample Volume (liters)		8-hour Time Weighted Average Results			
	a.m.	p.m.	a.m.	p.m.	Xylene (ppm)	Naphtha (mg/m^3)	Ethyl Benzene (ppm)	1-Methoxy-2-Propanol (ppm)
Spray Painter, 719 Booth	288	98	28.8	9.8	<0.34	<3.2	trace	trace
Spray Painter, 719 Booth	286	97	28.6	9.7	<0.46	<4.4	ND	ND
NIOSH Recommended Exposure Limit					100 TWA, 150 STEL	350 TWA, 1800 C	100 TWA 125 STEL	
OSHA Permissible Exposure Limit					100 TWA	2000 TWA	100 TWA	
ACGIH Threshold Limit Value					100 TWA, 150 STEL	1370 TWA	100 TWA 125 STEL	

Notes: Eight-hour time weighted average (TWA) exposures were calculated assuming that no exposure occurred during the unsampled portion of the shift. ppm means parts per million. mg/m^3 means milligrams of analyte per cubic meter of sampled air. Values for naphtha are expressed as mg/m^3 because naphtha is a mixture of hyrocarbons, while xylene is a compound with a defined formula, and thus a specific molecular weight. Molecular weight must be known to calculate ppm. STEL is a short term exposure limit. C indicates a ceiling limit, one which should not be exceeded during any part of the work day. A trace value is one which lies between the minimum detectable concentration and the minimum quantfiable concentration, of limited accuracy. ND means results were less than the MDC. < indicates that the results of one of the samples used to compute the TWA was a trace value or was ND. Based upon the maximum sample volume of 28.8 L, the minimum detectable concentrations (MDCs) were 0.08 ppm for xylene (all isomers) and ethyl benzene, 0.09 ppm for 1-methoxy-2-propanol, and 0.3 mg/m^3 for naphthas. The minimum quantifiable concentrations (MQCs) were

0.26 ppm for xylene (all isomers) and ethyl benzene, 0.31 ppm for 1-methoxy-2-propanol, and 1.1 mg/m^3 for naphthas. These values were also derived from the maximum sample volume of 28.8 L for this set of samples.

Figure 2: Qualitative Analysis of the Afternoon Charcoal Tube Sample, 180 Line Painter, Reliance Electric Company, Madison, Indiana, February 22, 1994, HETA 93-1084

File: C:\CHEMPC\DATA\MAR\0201002.D
Operator: AAG
Date Acquired: 8 Mar 94 3:12 pm
Method File: GROTE.M
Sample Name: SEQ 7952 CT-23/CS2
Misc Info: 30 M DB-1 SC20-400 SPLITLESS TP15-300 C
ALS vial:

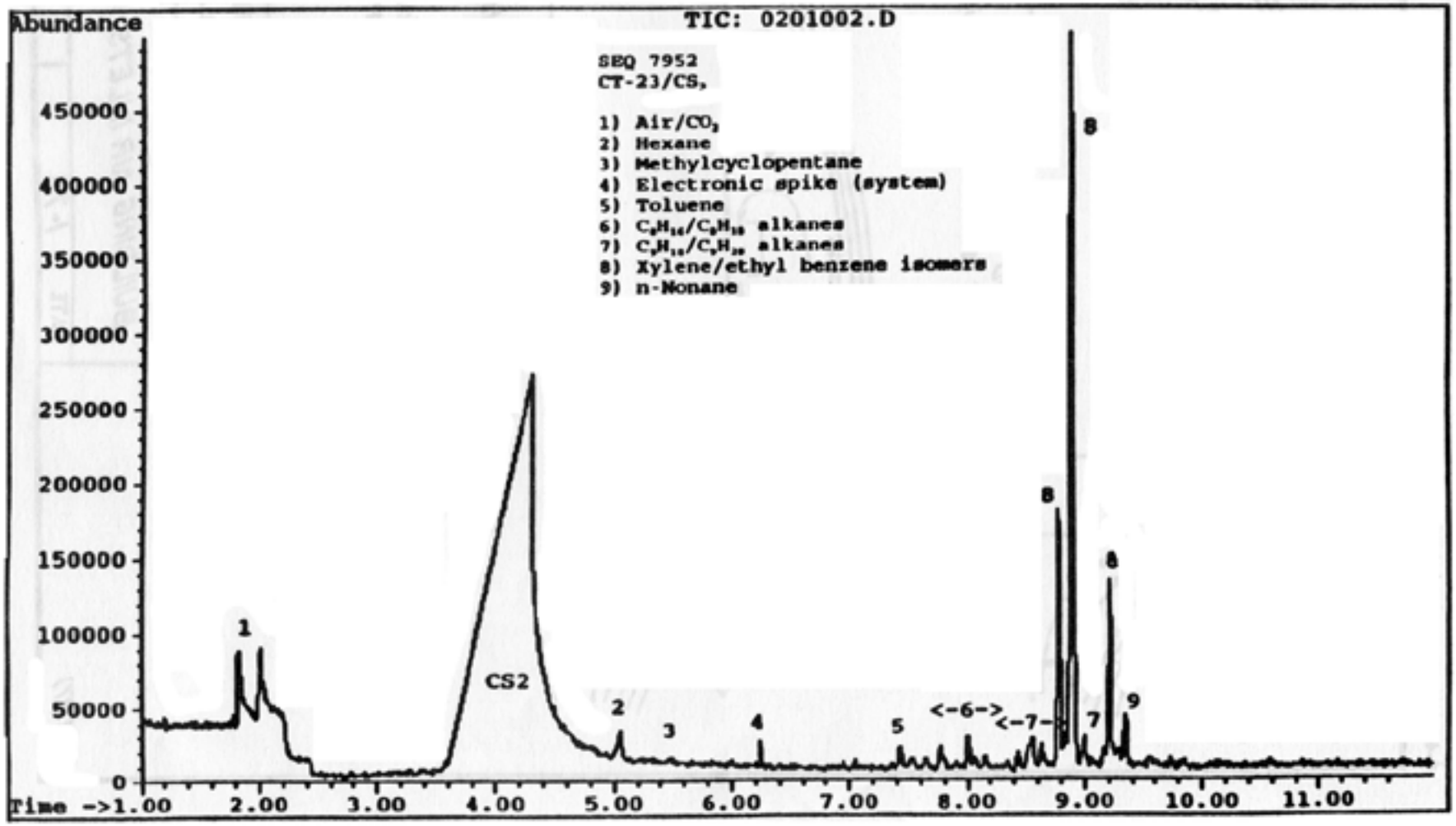


Figure 1: Qualitative Analysis of the Morning Charcoal Tube Sample, 180 Line Painter, Reliance Electric Company, Madison, Indiana, February 22, 1994, HETA 93-1084

File: C:\CHEMPC\DATA\MAR\0101001.D
Operator: AAG
Date Acquired: 8 Mar 94 2:42 pm
Method File: GROTE.M
Sample Name: SEQ 7952 CT-6/CS2
Misc Info: 30 M DB-1 SC20-400 SPLITLESS TP35-300 C
ALS vial: 1

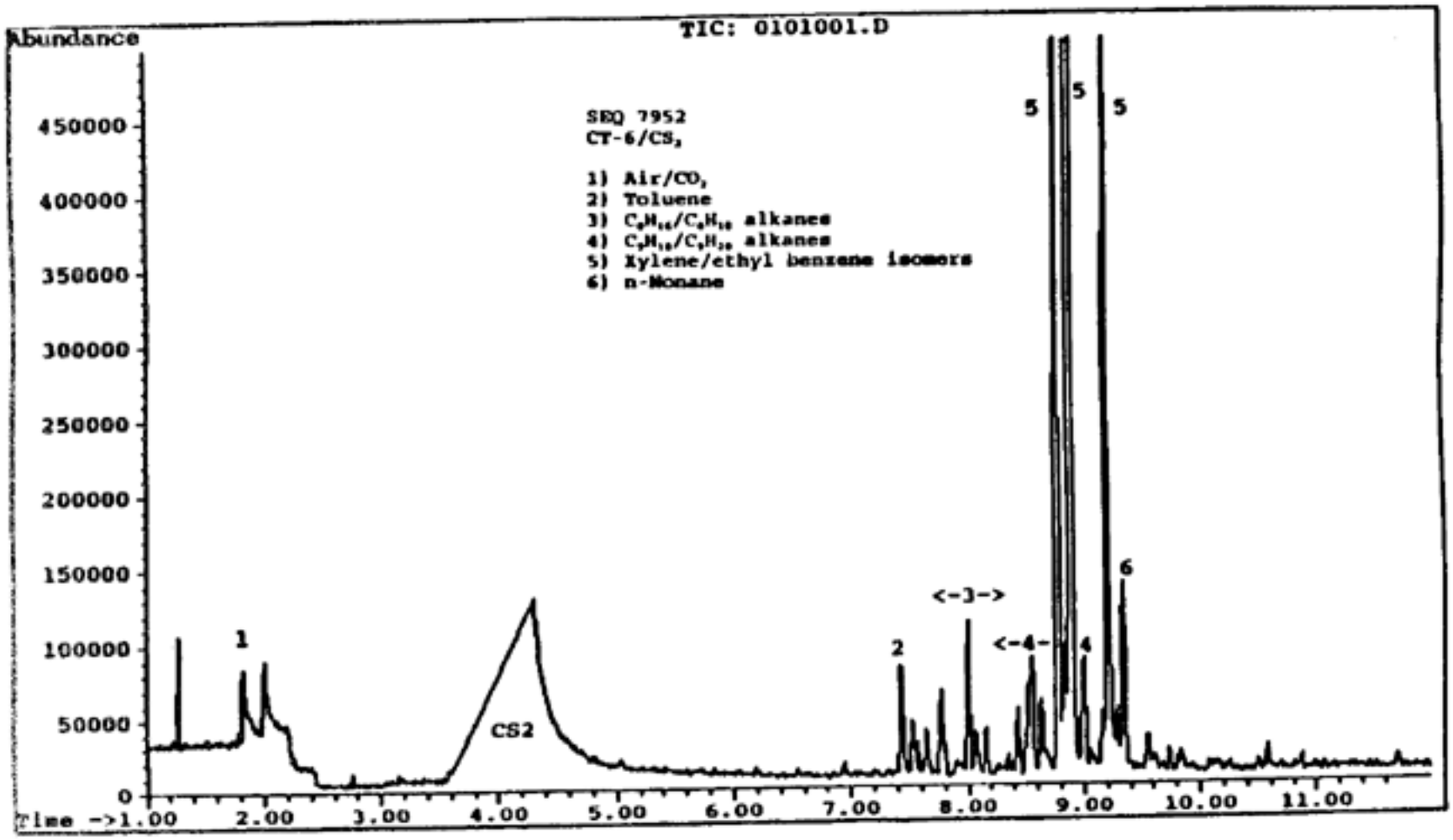
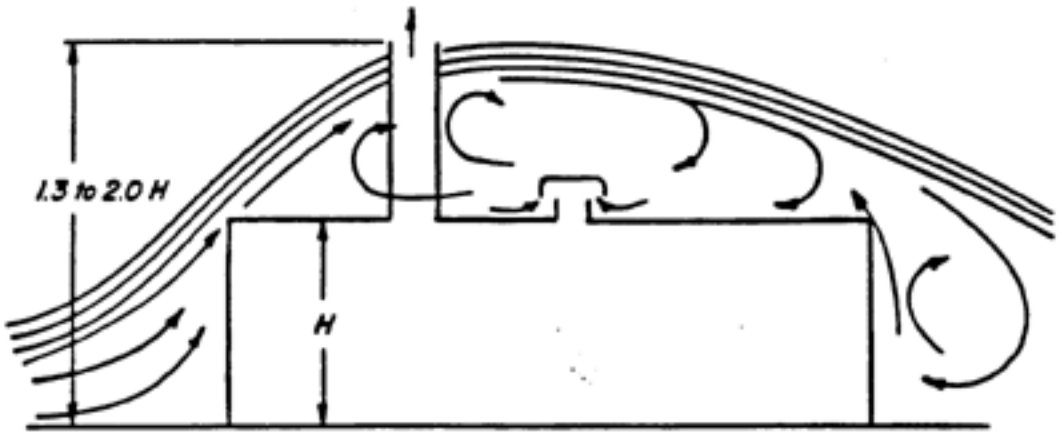
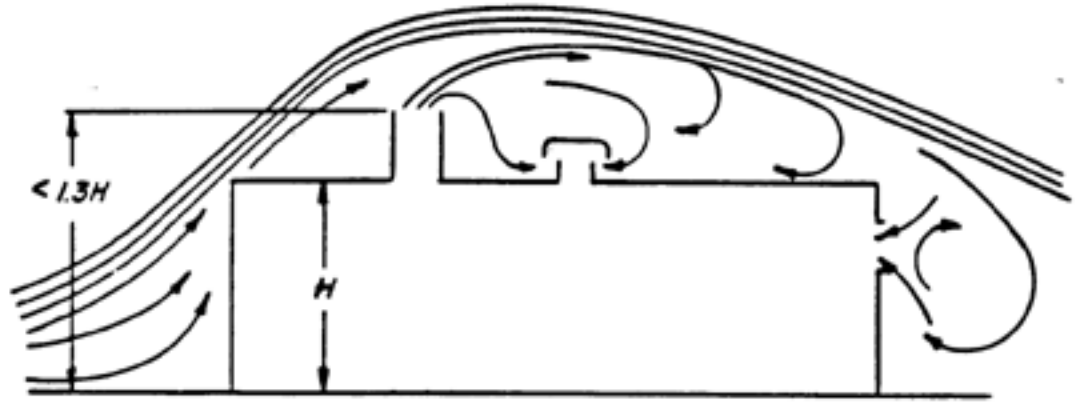


Figure 3: Guidance for Building Air Inlets and Outlets, Reliance Electric Company, Madison, Indiana, February 22, 1994, HETA 93-1084



GOOD

High discharge stack relative to building height, air inlet on roof.



POOR

Low discharge stack relative to building height, air inlet on roof and wall.

These guidelines apply only to the simple case of a low building without surrounding obstructions on reasonably level terrain.

See Fig. 6-24

AMERICAN CONFERENCE OF GOVERNMENTAL INDUSTRIAL HYGIENISTS	
BUILDING AIR INLETS AND OUTLETS	
DATE 1-76	Fig. 6-23

(Ref 87)