HAZARD EVALUATIONS AND TECHNICAL ASSISTANCE REPORT
HETA 90-092-L2083
BETHLEHEM STEEL
CHESTERTON, INDIANA
NOVEMBER 1990

Hazard Evaluations and Technical Assistance Branch
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I. SUMMARY

In December 1989, the United Steel Workers of America (USWA) Local 6787 contacted the National Institute for Occupational Safety and Health (NIOSH) and requested a Health Hazard Evaluation (HHE) at Bethlehem Steel in Chesterton, Indiana. The USWA asked NIOSH to investigate possible health hazards associated with exposure to gases and vapors at the 160" plate mill.

In response to the HHE request, NIOSH initiated medical and industrial hygiene evaluations. The medical evaluation included employee interviews, reviews of medical and benefits records, and a meeting with the company physician. The environmental evaluation included an industrial hygiene walk-through inspection, interviews with employees, an extensive air sampling survey, a review of company air monitoring data, and a review of material safety data sheets.

Based on employee interviews it is clear that a significant number of employees are experiencing symptoms of eye and respiratory irritation that can be linked to workplace exposures. Although some employees expressed concern about other health problems there was no evidence of serious occupational illness.

NIOSH air sampling documented low to moderate exposures to a variety of air contaminants, including iron oxide and other metals, sulfur dioxide, nitrogen dioxide and carbon monoxide. No individual contaminant was found at a concentration above the Occupational Safety and Health Administration (OSHA) Permissible Exposure Limit (PEL), the NIOSH Recommended Exposure Limit (REL) or the American Conference of Governmental Industrial Hygienists (ACGIH) Threshold Limit Value (TLV). However, because air sampling was conducted during the summer, the data are not representative of worst-case conditions. Virtually all employees who were interviewed expressed concern that exposure levels vary depending on the time of year, and reported that air quality can be much worse in the winter months.

No single contaminant was identified as the cause of eye and respiratory irritation. It seems likely that employee symptoms are caused by a combination of contaminants that are released by the cutting operations and by the heat-treat and tempering furnaces.

We recommend that exposure to irritants be controlled to minimize employee discomfort. Emissions from all sources can be controlled to some extent through increased and/or more consistent use of dilution ventilation. It may also be possible to reduce emissions from some

metal cutting operations through the use of local exhaust or other engineering controls. Specific recommendations for improved engineering controls are included at the end of this report.

II. BACKGROUND

In December 1989, the USWA asked NIOSH to conduct an HHE at the Bethlehem Steel 160" plate mill in Chesterton, Indiana. The request described a variety of health complaints that employees in that facility believed were caused by exposure to air contaminants.

Symptoms described by workers in the 160" plate mill included headaches, nausea and various forms of irritation. Adverse health effects were reported by crane operators and other workers in several areas of the building. The primary sources of the contamination were believed to be the metal burning or cutting operations and the various heat-treating and tempering operations. The request also mentioned the controlled rolling process and the production of Berge pipe as specific activities that seemed to be associated with an increase in air quality problems.

In response to the HHE request, NIOSH initiated medical and industrial hygiene evaluations. On April 3, 1990, an opening meeting was held at the Chesterton facility. The purpose and scope of the investigation were discussed and plans were made for the actual investigation to be started the following day. The medical evaluation was completed with a second visit which was made on April 6. The environmental evaluation was concluded with an industrial hygiene and air sampling survey that was conducted on July 17 and 18, 1990.

III. PROCESS DESCRIPTION

The Bethlehem Steel 160" plate mill is a large facility where several different operations are performed. The building construction is typical of the steel industry, with corrugated steel walls, a high ceiling, exhaust ventilation through the roof and many large doors and windows at ground level. The HHE focused on one end of the building where employees reported the most problems with air quality. The two major operations performed in that area are cutting or burning of steel plates and heat treating.

The cutting operation involves the use of gas-fired torches to square off or trim the steel plates that are produced in the 160" mill. Because the steel plates are quite thick, typically 1 to 4 inches, the cutting operation produces a large visible plume. Based on knowledge of similar operations, the plume is expected to contain metal fumes, nitrogen dioxide (NO_2) and carbon monoxide (CO). Because the steel plates may contain pockets of sulfur compounds, some oxides of sulfur may also be formed. When operating at full capacity, the cutting and burning operations could involve fifteen or more torches.

The heat treating operation uses three gas-fired furnaces for hardening and tempering of steel plates. Air contaminants that are likely to be generated include CO, NO_2, SO_2, and possibly products of partial combustion such as aldehydes and various hydrocarbons. All three furnaces appear to be vented directly into the work area and therefore may represent significant sources of air contamination. The rate of contaminant release from the ovens is likely to vary with operating conditions. Emission levels are expected to be higher during the light-up because the operating temperature is low and incomplete combustion is likely to occur. During the light-up, the furnace is reportedly fueled by coke oven gas, which some employees felt might also contribute to an increase in emissions. Although this suggestion is reasonable, there are currently no data to support it.

In addition to the major activities described above, there are also a number of other minor activities that generate air contaminants. Steel plates are moved between work areas and are "flipped" by overhead cranes for inspection. When the plates are dropped, a large dust cloud is produced. Although most of the dust is composed of large particles that settle out of the air quickly, this activity does contribute to the general haze in the air, and may contribute to the problem with eye and respiratory irritation.

The stencilling operation, in which paint is applied to the hot steel, also appears to be a source of potential contamination. The volume of aerosol or gas released at that point is relatively small, but the material has a strong odor and may be a concern for people who work close to, or above, the stenciling areas.

There also appeared to be some potential for aerosol or vapor generation in the rolling and leveling area. The most likely contaminants from that area would be metal fumes or dust. The possibility that the rolling area is a source of contaminants is supported by employee claims that respiratory irritation is worse during controlled rolling of Berge pipe.

Some questions were raised by employees who were concerned about the liquids that are sprayed on metals prior to rolling, or during the quenching operations. In some cases these sprays are just water, and in other cases they are water-based inorganic solutions. Some of the sprays may contain iodine, which is a potential irritant. Whether or not the material is carried into the workplace atmosphere is unknown, but it seems unlikely that these materials are present in sufficient quantity to produce adverse health effects.

Small scale cutting and grinding operations are also performed at various work stations, and these may generate some fumes and dust.

Because the contaminant sources are large and spread throughout the building, local exhaust or other types of source control are not used in most operations. The primary control mechanism is general dilution ventilation, which is provided through roof vents, exhaust fans, and open windows or doors. Employee exposure levels are primarily dependent on production rate, the amount of dilution air moving through the building and the location of the work stations relative to the emission sources. Most air movement is driven by thermal updrafts from the hot furnaces. Hot air rising from the heat-treat process is allowed to escape through permanently open gravity vents in the roof. This draws outside air into the building through openings closer to the floor, and establishes an air flow pattern that carries contaminants up and out of the building. This thermal exhaust system has been supplemented with the addition of seven fans that also exhaust at or near the roof. Although the volume of air exhausted by these fans is probably only a small fraction of the total, they may be important because they provide air movement in specific locations that might otherwise be stagnant. In addition, when the furnaces are not operating, thermal currents will be minimized, and the fans may be the only significant source of exhaust.

IV. MEDICAL EVALUATION

On April 3 and 6, 1990, NIOSH medical personnel conducted confidential interviews with 24 employees who were selected randomly from schedules provided by the company. Thirteen of the selected employees worked in the burning and heat-treat areas; four in the furnace, rolling or layout areas; and seven in the shear department.

Many employees reported episodes of poor air quality and poor visibility. In the burning and cutting area, workers reported increased smoke when reconditioning and cutting high carbon plates, airborne sulfur when sulfur pockets are hit, and airborne dust from plates being dropped.

In the heat-treat area, workers complained of emissions from the furnaces, which they felt were worse during the light-up and while tempering low-temperature steel. Some workers also felt that the use of coke oven gas in the furnaces caused problems with air quality. Coke oven gas is reportedly used in the non-continuous furnaces, in the "soak zone," and during the light-up and shut-down of the furnaces. Coke oven gas is reported to have a distinctive odor that is sometimes detected in the crane cabs.

Most heaters, employees who control the furnaces on the mill line, stay in enclosed pulpits. However, some reported operating cranes that are used to transfer plates to and from the non-continuous furnace. These workers reported exposure to SO_2 when torches are used to remove defects from the steel plates.

Most workers in the rolling area also stay in the enclosed pulpits. However, they report some increased dust production when the spray is reduced for control rolling or during line pipe production. The same problem was reported by workers in the shear department who described a red-brown dust that hangs in the air.

Workers in the lay-out and stencil area complained of dust and of smoke generated during the stencil and stamping operations.

A burning sensation in the eyes was widely reported, especially in the heat-treat area (6 of 13 employees) and by crane operators (3 of 6 employees) who work in cabs without air conditioning. Many employees in the burning, shearing and lay-out operations (7 of 14) reported cough. Others reported shortness of breath (4), bronchitis (2), nasal and sinus irritation (4), nose bleeds (1), headaches (4) or nausea (3). Most symptoms appeared to be temporally related to workplace exposures.

In addition to acute symptoms, several employees expressed concern about heart disease in themselves or co-workers. Heart disease is very common in the United States population, and has many causes, most of which are not related to work. Detection of work-related heart disease in the 160" plate mill would be difficult because it would require a much larger study population. However, furnaces are well known as a potential source of carbon monoxide (CO) and heat exposure. Employees with heart disease may be more susceptible to the effects of CO and heat exposure than other employees, especially during heavy work. Furthermore, chronic occupational exposure to CO is thought to be associated with heart disease. (Stern, F.B., Halperin, W.E., Hornung, R.W., Ringenberg, V.L. and McCammon, C.S. Heart Disease Mortality Among Bridge and Tunnel Officers Exposed to Carbon Monoxide. American Journal of Epidemiology. 1988; 128:1276-1288.) Improvements in ventilation, as recommended later in this report, would probably reduce the potential for exposure to CO and heat, and would likely decrease health risks to some employees.

In summary, the medical investigation found that a significant number of employees have experienced problems with eye, nose and lung irritation that appears to be linked to occupational exposures.

The mucous membrane and respiratory symptoms reported by many workers are recognized effects of SO_2 and NO_2. Exposure to the products of incomplete combustion, such as aldehydes, is also suggested by the irritant symptoms that were reported by the crane operators and workers in the lay-out and shearing areas. Heavy exposure to metal fumes and nuisance dust may also contribute to these types of problems.

Although some workers felt that irritation might be caused by components or coatings of the line pipe or Berge pipe, the increased irritation associated with these products is more likely due to a general increase in the dust level.

V. ENVIRONMENTAL EVALUATION AND AIR SAMPLING

The environmental evaluation consisted of an industrial hygiene walk-through inspection, interviews with employees, reviews of relevant Material Safety Data Sheets and company air monitoring records, and an extensive air sampling survey.

On a subjective basis, the general environmental quality appeared to be acceptable. Although there was a haze in the air, the conditions did not appear worse than would be expected in most heavy industrial operations. Air quality appeared to be better on July 17 and 18 than it was on April 3. This may have been because more doors and windows were open, because less cutting and burning was being done, or because the furnaces were down during the April visit. As noted earlier, the ventilation rate is dependent on the thermal currents produced by the furnaces, and may be less when the furnaces are not running.

The primary sources of visible contaminants appeared to be the cutting or burning operations and the dropping of steel plates from the overhead cranes. The three furnaces located in the heat-treating area vent directly into the work area and are an obvious source of carbon monoxide and products of incomplete combustion. Emissions appeared especially high during the furnace light-up. However, the light-up lasts for only a short time and does not appear to be a serious problem.

During informal discussions, a number of employees claimed that the air quality is frequently much worse than it was on the days of the investigation. It is likely that the air quality varies from day to day, and with the seasons. In winter, the air quality may be much worse due to the reduced level of ventilation. In fact, some workers reported that the smoke and fumes are sometimes so thick that the overhead cranes cannot be seen from the floor. The importance of factors such as weather and changes in the ventilation rate are difficult to assess during one or two brief visits, and can best be evaluated by employees and supervisors working in the area, or by the company's environmental control staff.

As part of the environmental assessment, the NIOSH investigators conducted both personal breathing zone (PBZ) and area air monitoring for a variety of potential contaminants. The first set of air samples was collected on April 3, between 9:00 AM and 3:00 PM. The survey included measurement of carbon monoxide, hydrogen chloride, inorganic acids, and metal fumes. All sampling on this initial survey was conducted in the cutting and burning area because the heat-treat area was shut down for maintenance. The second set of air samples was collected on July 17 during the 3:00 to 11:00 shift and included the furnace light-up. The third data set, collected on the morning shift of July 18, should represent conditions during an average summer day when the cutting and heat treating areas are in operation. The second and third data sets included measurement of total particulate or nuisance dust, metals, hydrocarbons, aldehydes, SO_2, NO_2 and CO.

Sampling locations were selected based on information gained in the initial walk-though or provided by employees and management. In general, pumps were placed in areas that were thought to represent the worst case exposures on the day of the investigation. These measurements may not be representative of exposures occurring in other areas or at other times. The specific sampling locations are indicated in Tables 1-9, along with the analytical results.

A. Air Sampling Results

1. Carbon Monoxide

Carbon monoxide is a colorless, odorless gas that is frequently generated by combustion processes. In the 160" plate mill, CO formation is expected in the cutting operations and from the heat-treat furnaces. While CO does not produce the irritant effects that were described by workers in this facility, over-exposure should be regarded as a significant health hazard. Exposure to high levels of CO reduces the blood's ability to carry oxygen and produces symptoms of headache, nausea and dizziness. At higher concentrations CO exposure can lead to a loss of consciousness and death.

Carbon monoxide levels were measured as part of each of the air sampling surveys. Data are presented in Table 1.

Preliminary results, obtained on April 3 with the long-term detector tubes, indicate that CO levels were well below the standards established by OSHA, NIOSH and ACGIH. Five samples indicated CO levels of less than 5 parts per million (ppm), or about 15% of the OSHA Permissible Exposure Limit (PEL), in the cutting and burning area. The furnaces, which are likely to be a major source of CO, were not running that day, so the CO that was detected was apparently generated by the cutting operations. The low levels indicate that the cutting operations themselves are not likely to produce hazardous concentrations of CO.

Continuous CO measurements were made on July 17 during the furnace light-up and on July 18, during normal operation. While most of the dosimeters detected only low levels of CO, a dosimeter placed in the cab of crane #724 recorded an average concentration of 29 ppm on July 18. The concentration appeared to increase throughout the day, and at one point reached a peak of near 50 ppm. The current NIOSH REL for CO calls for an 8-hour time-weighted average exposure of no more than 35 ppm, and a maximum peak exposure of no more than 200 ppm.

Although the levels recorded in this survey do not exceed the NIOSH REL or OSHA regulations, they may indicate a potential problem with ventilation in the southwest corner on the building. It should also be noted that CO exposures may be more hazardous to those individuals in the work force who have heart disease.

2. Hydrogen Chloride

Hydrogen chloride levels were measured on April 3 with long-term detector tubes. All levels were below the limit of detection, which is about 2 ppm for the sampling conditions used in this investigation. The preliminary walk-through did not locate any significant sources, so the low readings are not unexpected.

3. Inorganic Acids

Inorganic acids were measured by collection on silica gel followed by analysis using ion chromatography. The results are presented in Table 2. Hydrochloric acid was not found. Sulfuric acid was measured at concentrations of 0.1 to 0.2 mg/m^3, or 10 to 20% of the NIOSH recommended exposure limit (REL) and the ACGIH TLV. At these concentrations it appears unlikely that inorganic acids are responsible for employee health complaints.

4. Total Particulate Material

Total particulate levels were measured on July 17 and 18 by NIOSH method #0500 and are shown in Table 3. Fifteen samples were collected on PVC filters and the mass of the collected dust was measured gravimetrically. An average concentration of 34 mg/m^3 was measured at the shaper-cutter, indicating that there is a significant amount of fume produced by each torch. However, as shown in Table 3, the highest concentration that was measured in a work area was only 1.55 mg/m^3, which is about 15% of the ACGIH TLV for total particulate, not otherwise classified.

5. Metals

Air sampling conducted on April 3 and on July 17 and 18 included collection of airborne particulates on filters for elemental analysis. The measured concentrations of iron, nickel, chromium, and manganese are reported in Tables 4-7. As expected, the data show that iron, probably in the form of iron oxide, was the major component of the airborne particulate, with aluminum, calcium, chromium, copper, magnesium, manganese, molybdenum, nickel and zinc being detected in one or more samples. As expected, the highest concentrations were recorded in area samples taken at the shaper-cutter. These samples represent the highest possible exposure, and are not representative of actual exposures that employees would be expected to experience. The highest concentrations of metal fumes and/or dust that were measured in actual work areas were found in the breathing zones of employees working in the various cutting operations.

Iron was found at time-weighted average concentrations ranging from a low of less than 0.01 to a high of 21.1 milligrams per cubic meter (mg/m^3) in an area sample taken at the shaper-cutter. The highest measured concentration that would represent actual employee exposures was 1.70 mg/m^3, which was recorded on a PBZ sampler worn by a process helper in the cut and burn area.

The maximum concentration of iron detected in any PBZ sample or crane cab represents a level that is less than 40% of the ACGIH TLV, which is set at 5 mg/m^3. Based on this data, the iron levels measured on the day of the survey should not present a health hazard.

Other than iron, the major components of collected particulates were nickel. chromium and manganese. Although the measured concentrations were well below established standards, it should be noted that NIOSH classifies chromium and nickel as potential carcinogens, and recommends that exposures be limited to the lowest feasible level.

6. Sulfur Dioxide

On July 17 and 18, SO_2 was measured by NIOSH method #6004. This method allows the particulate sulfite and sulfate to be measured independent of sulfur dioxide gas.

Samples were collected in both the cut and burn area and in the heat-treat area. No particulate sulfite was detected in any sample. Sulfate and SO_2 were detected, but levels were well below any applicable standards. Even area samples taken directly at the shaper revealed relatively low SO_2 concentrations of about 0.3 mg/m^3. These results seem to indicate that SO_2 is not a major constituent of the cutting emissions and is probably not a significant problem in the 160" plate mill. However, it should be noted that the analytical results were somewhat ambiguous due to poor reproducibility and that SO_2 levels may vary depending on the type of steel being produced or cut.

7. Nitrogen Dioxide

Six to eight hour time-weighted average NO_2 levels were measured on July 17 and 18 using Palmes tubes according to NIOSH method #6700. Nitrogen dioxide is produced by gas welding operations and can be expected in many operations that involve intense heating of air. Because NO_2 is a powerful irritant, and at high concentrations can cause severe disease, NIOSH, OSHA and ACGIH have established either ceiling or Short-Term Exposure Limits (STELs). NIOSH recommends a 15 minute time weighted average exposure limit of 1 ppm, which matches the recently updated OSHA regulation. ACGIH recommends a STEL of 5 ppm and TLV of 3 ppm.

The sampling procedures used in this study do not provide short term exposure data and therefore can not be easily interpreted by comparison with OSHA or NIOSH criteria. The NO_2 levels in the plate mill were higher than might have been expected, but were well below the TLV, with concentrations in the work areas ranging from 0.09 ppm up to 0.17 ppm. An average concentration of 0.47 ppm was recorded at the shaper-cutter, indicating that the cutting operations may be a major source of this contaminant. Nitrogen dioxide was also measured at moderate concentrations near the hardening furnace, indicating that some NO_2 may also be produced in that area.

Although the long-term average values are difficult to interpret, these results indicate that NO_2 may be a significant contributor to the reports of respiratory irritation and should probably be a focus of future monitoring and control activities.

8. Aldehydes

Aldehydes were measured on July 17 and 18 using NIOSH method #2539. This method is used primarily as a screening technique, and is most useful for determining whether or not aldehydes are present. If aldehydes are present, the concentration can only be estimated, and the results should not be interpreted as a precise measurement.

Personal and area samples collected in the heat-treating area did detect formaldehyde, which is a common product of incomplete combustion. The concentrations were estimated to range from non-detectable to about 50% of the current TLV. Based on the concentrations measured in these studies, aldehydes do not appear to be a major contributor to employee complaints of eye and respiratory irritation, but if levels are higher in the winter, further monitoring would be warranted.

9. Hydrocarbons

The concentration of hydrocarbon vapors in the heat treat area was measured on July 17 and 18 using NIOSH method #1500. Area and personal samples were collected using activated charcoal and were analyzed using gas chromatography-mass spectrometry (GC-MS). Although the GC-MS technique is a powerful and sensitive method, no contaminants were detected by this system.

VI. DISCUSSION

A NIOSH HHE cannot always provide a complete or comprehensive assessment of environmental conditions, or of all possible employee exposures. In this particular case, the size of the 160" plate mill, the large number of possible contaminants, and the complexity of the work environment made a complete assessment of exposures impractical. Air quality in the rolling mill is likely to vary from day to day depending on the production rate, the specific type of plates being processed and the weather.

Despite these limitations, the results reported here should provide an accurate description of the work environment on a typical summer day, and may provide a qualitative indication of the types of problems that can be anticipated in the winter. These data can be used to determine the types of contaminants that are present and to locate likely sources that should be the focus of control efforts.

Air sampling conducted for this survey did not find evidence of specific chemical exposures in excess of current evaluation criteria. However, a high percentage of employees did report a history of eye and respiratory irritation, and a number of contaminants were identified that might contribute to those problems.

The reported problems seem to be seasonal. If, as several employees indicated, contaminant levels are significantly higher during the winter, then mixed exposure to NO_2, SO_2, aldehydes, iron oxide and other particulate materials may be responsible for the reported eye and respiratory irritation.

Previous NIOSH HHEs have frequently found that irritant symptoms are associated with cutting and welding operations that generate high levels of metal fume, NO_2 and SO_2. Although iron oxide is the major component of the fume, there is currently no evidence that the irritation is caused by that component. In this case, it is more likely that irritant effects are caused by exposure to NO_2 and are aggravated by exposure to high concentrations of particulate and possibly aldehydes. The current data do not seem to indicate that SO_2 is likely to be a major contributor to the problem.

Even without identifying a specific contaminant that might be responsible for irritant effects, it should be possible to alleviate symptoms through general improvements in air quality and environmental controls. Although the dilution ventilation system used in this facility is a standard control technology in the hot-process industries, it does have some limitations. In order for this system to be effective, it is important that plenty of make-up air be provided at ground level by keeping doors and windows open. In addition, on days when the furnaces are down, the amount of air movement will be reduced, and fumes from the cutting operations may build up to unacceptable levels.

Another problem with the use of dilution ventilation is that it carries contaminants past the cranes and may subject the operators to high levels of exposure. In order to reduce crane operator exposures, and to provide a more comfortable work environment, some of the crane cabs do have air conditioning and/or air filters. A good filtration system can be expected to remove most of the particulate matter, and should therefore minimize exposure to metal fumes and dust. However, the air conditioning units may not be an effective approach to removing gases such as CO, NO_2 and SO_2.

The data collected for this survey also raise the issue of possible CO exposures, which may be related to employee reports of headaches. If ventilation levels are significantly reduced in winter, CO levels above the tempering and hardening furnaces may be a problem. Because CO exposures present a significant health hazard, further investigation by the company health and safety staff may be required.

VII. CONCLUSIONS AND RECOMMENDATIONS

The NIOSH investigation found that air quality was acceptable at the time of the evaluation, and was probably comparable to that found in other similar work environments. It appears likely that the air quality on the day of the investigation was better than it has been on some other occasions. Although the walk-through survey identified several sources of air contamination, and the air sampling survey detected several potential irritants, there is no evidence of exposures above the OSHA PELs, ACGIH TLVs or NIOSH RELs.

Medical interviews revealed that a high proportion of employees have experienced mild to severe eye and respiratory irritation. Some heart disease was also reported, but an investigation to find evidence of a link to the work environment is beyond the scope of this HHE. No other serious occupational illness was reported.

Because air sampling was conducted at a time when air quality was relatively good, the specific cause of irritation could not be identified. Data collected for this survey seem to indicate that the primary source of irritants is the cutting and burning operation. Irritant effects probably result from exposure to a mixture of materials. It appears that NO_2, particulates and possibly aldehydes, may be the most significant contributors.

Where possible, employee problems with respiratory or eye irritation and headaches should be addressed with improved environmental controls including increased and/or more consistent use of dilution ventilation. Specific recommendations that would be expected to improve air quality in the 160" rolling mill are presented here:

1. Improve maintenance of the ventilation system. At the time of the first NIOSH visit only three of the seven ventilation fans that had been installed were operational. Since the fans are already in place, repair and maintenance should be given a high priority. While these fans exhaust a relatively small volume of air compared to the thermal exhaust system, they may play an important role in improving air flow in certain parts of the building. This is especially true on days when the heat-treat furnaces are not operating and providing thermal currents.

2. Install one or more exhaust fans in the southwest corner of the building. Reports from people working in the area indicate that air quality problems are especially severe in the southwest corner of the building, and in crane #724. It is possible that air flow patterns do allow contaminated air to become stagnant in that

corner. This is supported by the high CO readings in the cab of crane #724. The situation should be investigated further with ventilation smoke bombs or candles, and could probably be resolved with the addition of exhaust fans.

3. Conduct further air sampling under worst-case conditions. Because the NIOSH survey was conducted at a time when doors and windows could be left open, the air sampling data may not provide a good indicator of conditions in the winter. In order to determine whether or not any specific contaminant can reach unacceptable concentrations, air sampling should be conducted on a day that represents worst-case conditions. Based on data collected during the evaluation, it is recommended that further monitoring include measurement of CO, NO_2, aldehydes and total dust and iron.

4. Install air conditioning or filters for all crane cabs. At the time of the NIOSH visits, the pulpit and some of crane cabs were air conditioned. Air conditioning or filtration units should be provided for all crane operators. Many of the air contaminants are particulates which could be filtered with relatively simple systems. However, employees should be aware that filtration units will not remove CO or gaseous irritants such as NO_2 and aldehydes.

5. Provide sufficient make-up air throughout the year. Most employee complaints are centered on the need for better ventilation during the winter. Although temperature control must be a consideration, it is important that sufficient make-up air be provided at all times. If the building is sealed too tightly, the thermally driven ventilation system will not function as intended, and contaminant levels might become unacceptable. The low contaminant levels, and lack of irritation problems in the summer months, demonstrate that dilution ventilation can be an effective control method if sufficient make-up air is provided.

6. Investigate use of local exhaust. Air quality in the 160" plate mill could be significantly improved through the use local exhaust systems or other technologies that control emissions at the source. Although local controls would be difficult to implement in many areas, emissions from some operations could be at least partially controlled. For example, the torches on the shaper could be fitted with a exhaust system, and the emissions from the stenciling operation could be captured with a canopy hood. Other types of local controls, such as the submerged cutting system that was discussed during the initial visit, should also be considered.

7. Minimize CO exposures and heat stress of employees with known heart disease. Possible exposures to CO and heat-stress should be monitored and controlled to prevent adverse health effects. Although employees with heart disease may be more affected by these exposures, even healthy persons may be affected.

8. Install improved guards on the hardening and tempering furnaces and institute a "no-removal" policy. During the light-up and preparation for light-up, employees were observed removing guards from the sides of the hardening furnace and climbing directly above the moving chains and gears. Although safety issues of this type were not the focus of the NIOSH investigation, this practice is an obvious violation of basic safety principals and should be stopped.

Table 1
Measurement of Carbon Monoxide
Bethlehem Steel, 160" Plate Mill Chesterton, Indiana
HETA 90-092
July 17-18, 1990

DATE	SHIFT	LOCATION	SAMPLING TIME	Concentration (ppm) Average	Concentration (ppm) Peak
April 3, 1990	7:00-3:00	Crane Operator	239 minutes	2	NA
April 3, 1990	7:00-3:00	Crane #708	199 minutes	ND	NA
April 3, 1990	7:00-3:00	Cut & Burn Area	240 minutes	2	NA
April 3, 1990	7:00-3:00	Shaper-Cutter	237 minutes	2	NA
July 17, 1990	3:00-11:00	Furnace Operator	348 minutes	ND	ND
July 17, 1990	3:00-11:00	Furnace Checker	345 minutes	ND	ND
July 17, 1990	3:00-11:00	Crane #720	380 minutes	ND	11
July 17, 1990	3:00-11:00	Crane #724	342 minutes	ND	ND
July 18, 1990	7:00-3:00	Heat-Treat Helper	355 minutes	ND	ND
July 18, 1990	7:00-3:00	Painter - Stamper	350 minutes	2	3
July 18, 1990	7:00-3:00	Quality Con. Cutter	340 minutes	ND	7
July 18, 1990	7:00-3:00	Crane #724	305 minutes	29	65

Evaluation Criteria

Exposure Standard	Concentration (ppm)
OSHA PEL	35
OSHA CEILING	200
ACGIH TLV	50
NIOSH REL	35
NIOSH CEILING	200

Abbreviations

ppm : Parts Per Million
OSHA : Occupational Safety and Health Administration
PEL : Permissible Exposure Limit (8 hour time-weighted average exposure)
CEILING : The concentration that should not be exceeded at any time.
ACGIH : American Conference of Governmental Industrial Hygienists
TLV : Threshold Limit Value (8 hour time weighted average exposure)
NA : Not Applicable or Not Measured
NIOSH : National Institute for Occuaptional Safety and Health
REL : Recommended Exposure Limit (8 hour time weighted average exposure)
ND : Not Detected (Concentration < 2ppm)

Table 2
Measurement of Inorganic Acids
Bethlehem Steel, 160" Plate Mill
Chesterton, Indiana
HETA 90-092
April 3, 1990

DATE	SHIFT	LOCATION	SAMPLING TIME	AVERAGE CONC. (mg/m^3) HCl	H_2SO_4
April 3, 1990	7:00- 3:00	Walk near crane #729	277 minutes	ND	0.10
April 3, 1990	7:00- 3:00	Shaper (burn and cut)	257 minutes	ND	0.20
April 3, 1990	7:00- 3:00	Crane #729	298 minutes	ND	0.10
April 3, 1990	7:00- 3:00	Burn and Cut area	240 minutes	ND	0.10

Evaluation Criteria

Exposure Standard	HCL (mg/m^3)	H_2SO_4 (mg/m^3)
OSHA PEL	NA	1
OSHA CEILING	7	NA
ACGIH TLV	NA	1
ACGIH STEL	NA	3
ACGIH CEILING	7.5	NA
NIOSH REL	NA	1

Abbreviations

mg/m^3 : milligrams of contaminant per cubic meter of air
OSHA : Occupational Safety and Health Administration
ACGIH : American Conference of Governmental Industrial Hygienists
TLV : Threshold Limit Value (8 hour exposure)
PEL : Permissible Exposure Limit (8 hour exposure)
STEL : Short Term Exposure Limit (15 minute exposure)
CEILING : The concentration that should not be exceeded at any time.
NIOSH : National Institute for Occuaptional Safety and Health
REL : Recommended Exposure Limit (8 hour time weighted average exposure)
NA : Not Applicable or Not Measured
ND : Not Detected (Limits of Detection are 3 to 5 ug per sample.)

Table 3
Measurement of Total Airborne Particulate
Bethlehem Steel, 160" Plate Mill
Chesterton, Indiana
HETA 90-092
July 17-18, 1990

DATE	SHIFT	SAMPLING LOCATION	TIME MINUTES	AVERAGE CONC. (mg/m3)
July 17 1990	3:00-11:00	Car Bottom Furnace	351	0.41
July 17, 1990	3:00-11:00	Hardening Furnace	398	0.07
July 17, 1990	3:00-11:00	Crane #720	377	ND
July 17, 1990	3:00-11:00	Lay-out Area	349	0.19
July 17, 1990	3:00-11:00	Crane #724	342	0.11
July 18, 1990	7:00- 3:00	Crane #724	301	0.08
July 18, 1990	7:00- 3:00	Tempering Furnace	321	0.28
July 18, 1990	7:00- 3:00	Tempering Furnace	324	0.10
July 18, 1990	7:00- 3:00	Hardening Furnace	304	0.14
July 18, 1990	7:00- 3:00	Lay-Out Area	306	0.46
July 18, 1990	7:00- 3:00	SW corner, 3rd level	250	0.28
July 18, 1990	7:00- 3:00	Shaper-Cutter (area)	197	34
July 18, 1990	7:00- 3:00	Shaper-Cutter (area)	90	28
July 18, 1990	7:00- 3:00	Reconditioning Area	284	1.25
July 18, 1990	7:00- 3:00	Crane # 728	332	1.55

Evaluation Criteria

Exposure Standard	Total Dust (mg/m^3)
OSHA PEL	15
ACGIH TLV	10

Abbreviations

mg/m^3 : milligrams of contaminant per cubic meter of air
OSHA : Occupational Safety and Health Administration
PEL : Permissible Exposure Limit (8 hour exposure)
ACGIH : American Conference of Governmental Industrial Hygienists
TLV : Threshold Limit Value (8 hour exposure)
NA : Not Applicable or Not Measured
ND : Not Detected (Limit of Detection is approximately 0.01 mg.)

Table 4
Measurement of Iron Oxide Dust and Fume
Bethlehem Steel, 160" Plate Mill
Chesterton, Indiana
HETA 90-092
April 3, July 17-18, 1990

DATE	SHIFT	LOCATION	TIME MINUTES	AVERAGE CONC. (mg/m^3)
April 3, 1990	7:00- 3:00	Portable Burner	328	1.30
April 3, 1990	7:00- 3:00	Shaper	301	1.10
April 3, 1990	7:00- 3:00	Process Helper	352	1.70
April 3, 1990	7:00- 3:00	Crane #729	240	0.60
July 17, 1990	3:00-11:00	Car Bottom Furnace	351	0.19
July 17, 1990	3:00-11:00	Hardening Furnace	398	0.03
July 17, 1990	3:00-11:00	Crane #720	377	0.01
July 17, 1990	3:00-11:00	Lay-out Area	349	0.07
July 17, 1990	3:00-11:00	Crane #724	342	0.07
July 18, 1990	7:00- 3:00	Crane #724	301	0.04
July 18, 1990	7:00- 3:00	Tempering Furnace	321	0.12
July 18, 1990	7:00- 3:00	Tempering Furnace	324	0.07
July 18, 1990	7:00- 3:00	Hardening Furnace	304	0.05
July 18, 1990	7:00- 3:00	Lay-Out Area	306	0.25
July 18, 1990	7:00- 3:00	SW corner	250	0.14
July 18, 1990	7:00- 3:00	Shaper-Cutter	197	21.10
July 18, 1990	7:00- 3:00	Shaper-Cutter	90	15.00
July 18, 1990	7:00- 3:00	Reconditioning Area	284	0.58
July 18, 1990	7:00- 3:00	Crane # 728	332	0.87

Evaluation Criteria

Exposure Standard	Fume (mg/m^3)
OSHA PEL	10
ACGIH TLV	5

Abbreviations

mg/m^3 : milligrams of contaminant per cubic meter of air
OSHA : Occupational Safety and Health Administration
PEL : Permissible Exposure Limit (8 hour exposure)
ACGIH : American Conference of Governmental Industrial Hygienists
TLV : Threshold Limit Value (8 hour exposure)

Table 5
Measurement of Nickel Dust and Fume
Bethlehem Steel, 160" Plate Mill
Chesterton, Indiana
HETA 90-092
April 3, July 17-18, 1990

DATE	SHIFT	LOCATION	TIME MINUTES	AVERAGE CONC. (mg/m^3)
April 3, 1990	7:00- 3:00	Portable Burner	328	0.01
April 3, 1990	7:00- 3:00	Shaper	301	<0.01
April 3, 1990	7:00- 3:00	Process Helper	352	<0.01
April 3, 1990	7:00- 3:00	Crane #729	240	<0.01
July 17, 1990	3:00-11:00	Car Bottom Furnace	351	ND
July 17, 1990	3:00-11:00	Hardening Furnace	398	ND
July 17, 1990	3:00-11:00	Crane #720	377	ND
July 17, 1990	3:00-11:00	Lay-out Area	349	ND
July 17, 1990	3:00-11:00	Crane #724	342	ND
July 18, 1990	7:00- 3:00	Crane #724	301	ND
July 18, 1990	7:00- 3:00	Tempering Furnace	321	ND
July 18, 1990	7:00- 3:00	Tempering Furnace	324	ND
July 18, 1990	7:00- 3:00	Hardening Furnace	304	ND
July 18, 1990	7:00- 3:00	Lay-Out Area	306	ND
July 18, 1990	7:00- 3:00	SW corner	250	ND
July 18, 1990	7:00- 3:00	Shaper-Cutter Area	197	0.036
July 18, 1990	7:00- 3:00	Shaper-Cutter Area	90	0.050
July 18, 1990	7:00- 3:00	Reconditioning Area	284	ND
July 18, 1990	7:00- 3:00	Crane # 728	332	ND

Evaluation Criteria

Exposure Standard	Fume (mg/m^3)
OSHA PEL	1
ACGIH TLV	1

Abbreviations

mg/m^3 : milligrams of contaminant per cubic meter of air
OSHA : Occupational Safety and Health Administration
PEL : Permissible Exposure Limit (8 hour exposure)
ACGIH : American Conference of Governmental Industrial Hygienists
TLV : Threshold Limit Value (8 hour exposure)
ND : Not Detected (Limit of Detection is about 1 ug per sample.)

Table 6
Measurement of Chromium Dust and Fume
Bethlehem Steel, 160" Plate Mill
Chesterton, Indiana
HETA 90-092
April 3, July 17-18, 1990

DATE	SHIFT	LOCATION	TIME MINUTES	AVERAGE CONC. (mg/m^3)
April 3, 1990	7:00- 3:00	Portable Burner	328	<0.01
April 3, 1990	7:00- 3:00	Shaper	301	<0.01
April 3, 1990	7:00- 3:00	Process Helper	352	<0.01
April 3, 1990	7:00- 3:00	Crane #729	240	ND
July 17, 1990	3:00-11:00	Car Bottom Furnace	351	ND
July 17, 1990	3:00-11:00	Hardening Furnace	398	ND
July 17, 1990	3:00-11:00	Crane #720	377	ND
July 17, 1990	3:00-11:00	Lay-out Area	349	ND
July 17, 1990	3:00-11:00	Crane #724	342	ND
July 18, 1990	7:00- 3:00	Crane #724	301	ND
July 18, 1990	7:00- 3:00	Tempering Furnace	321	ND
July 18, 1990	7:00- 3:00	Tempering Furnace	324	ND
July 18, 1990	7:00- 3:00	Hardening Furnace	304	ND
July 18, 1990	7:00- 3:00	Lay-Out Area	306	ND
July 18, 1990	7:00- 3:00	SW corner, 3rd level	250	ND
July 18, 1990	7:00- 3:00	Shaper-Cutter (area)	197	0.03
July 18, 1990	7:00- 3:00	Shaper-Cutter (area)	90	0.02
July 18, 1990	7:00- 3:00	Reconditioning Area	284	ND
July 18, 1990	7:00- 3:00	Crane # 728	332	ND

Evaluation Criteria

Exposure Standard	Fume (mg/m^3)
OSHA PEL	1.0
ACGIH TLV	0.5

Abbreviations

mg/m^3 : milligrams of contaminant per cubic meter of air
OSHA : Occupational Safety and Health Administration
PEL : Permissible Exposure Limit (8 hour exposure)
STEL : Short Term Exposure Limit (15 minute exposure)
ACGIH : American Conference of Governmental Industrial Hygienists
TLV : Threshold Limit Value (8 hour exposure)
ND : Not Detected (Limit of Detection is about 1 ug per sample.)

Table 7
Measurement of Manganese Dust and Fume
Bethlehem Steel, 160" Plate Mill
Chesterton, Indiana
HETA 90-092
April 3, July 17-18, 1990

DATE	SHIFT	LOCATION	TIME MINUTES	AVERAGE CONC. (mg/m^3)
April 3, 1990	7:00-3:00	Portable Burner	328	0.01
April 3, 1990	7:00-3:00	Shaper	301	0.01
April 3, 1990	7:00-3:00	Process Helper	352	0.02
April 3, 1990	7:00-3:00	Crane #729	240	0.01
July 17, 1990	3:00-11:00	Car Bottom Furnace	351	ND
July 17, 1990	3:00-11:00	Hardening Furnace	398	ND
July 17, 1990	3:00-11:00	Crane #720	377	ND
July 17, 1990	3:00-11:00	Lay-out Area	349	ND
July 17, 1990	3:00-11:00	Crane #724	342	ND
July 18, 1990	7:00-3:00	Crane #724	301	ND
July 18, 1990	7:00-3:00	Tempering Furnace	321	ND
July 18, 1990	7:00-3:00	Tempering Furnace	324	ND
July 18, 1990	7:00-3:00	Hardening Furnace	304	ND
July 18, 1990	7:00-3:00	Lay-Out Area	306	ND
July 18, 1990	7:00-3:00	SW corner, 3rd level	250	ND
July 18, 1990	7:00-3:00	Shaper-Cutter (area)	197	0.30
July 18, 1990	7:00-3:00	Shaper-Cutter (area)	90	0.20
July 18, 1990	7:00-3:00	Reconditioning Area	284	0.01
July 18, 1990	7:00-3:00	Crane # 728	332	0.02

Evaluation Criteria

Exposure Standard	Dust (mg/m^3)
OSHA PEL	1
OSHA STEL	3
ACGIH TLV	5

Abbreviations

mg/m^3 : milligrams of contaminant per cubic meter of air
OSHA : Occupational Safety and Health Administration
PEL : Permissible Exposure Limit (8 hour exposure)
STEL : Short Term Exposure Limit (15 minute exposure)
ACGIH : American Conference of Governmental Industrial Hygienists
TLV : Threshold Limit Value (8 hour exposure)
ND : Not Detected (Limit of Detectection is about 1 ug per sample.)

Table 8
Measurement of Sulfur Dioxide
Bethlehem Steel, 160" Plate Mill
Chesterton, Indiana
HETA 90-092
July 17-18, 1990

DATE	SHIFT	LOCATION	SAMPLING TIME	AVERAGE CONC. (mg/m^3) SULFATE	SULFITE	SO_2
July 17, 1990	3:00-11:00	Car Bottom Furnace	350 minutes	ND	ND	ND
July 17, 1990	3:00-11:00	Hardening Furnace	398 minutes	ND	ND	ND
July 17, 1990	3:00-11:00	Crane #720	377 minutes	ND	ND	ND
July 17, 1990	3:00-11:00	Lay-out Area	350 minutes	ND	ND	ND
July 17, 1990	3:00-11:00	Crane #724	342 minutes	ND	ND	ND
July 18, 1990	7:00-3:00	Crane #724	301 minutes	ND	ND	ND
July 18, 1990	7:00-3:00	Tempering Furnace	321 minutes	ND	ND	ND
July 18, 1990	7:00-3:00	Tempering Furnace	324 minutes	ND	ND	ND
July 18, 1990	7:00-3:00	Hardening Furnace	304 minutes	ND	ND	ND
July 18, 1990	7:00-3:00	Lay-Out Area	306 minutes	0.01	ND	0.01
July 18, 1990	7:00-3:00	SW corner, 3rd level	250 minutes	ND	ND	ND
July 18, 1990	7:00-3:00	Shaper-Cutter (area)	197 minutes	0.30	ND	0.30
July 18, 1990	7:00-3:00	Shaper-Cutter (area)	90 minutes	0.30	ND	0.30
July 18, 1990	7:00-3:00	Crane #729	229 minutes	0.01	ND	0.01
July 18, 1990	7:00-3:00	Crane # 728	332 minutes	0.02	ND	0.02

Evaluation Criteria

Exposure Standard	SO_2 (mg/m^3)
OSHA PEL	5.0
OSHA STEL	10.0
ACGIH TLV	5.2
ACGIH STEL	13.0
NIOSH REL	1.3

Abbreviations

mg/m^3 : milligrams of contaminant per cubic meter of air
OSHA : Occupational Safety and Health Administration
PEL : Permissible Exposure Limit (8 hour exposure)
STEL : Short Term Exposure Limit (15 minute exposure)
ACGIH : American Conference of Governmental Industrial Hygienists
TLV : Threshold Limit Value (8 hour exposure)
NIOSH : National Institute for Occuaptional Safety and Health
REL : Recommended Exposure Limit (8 hour time weighted average exposure)
ND : Not Detected (Limit of Detection for SO_2 is 2 ug per sample.)