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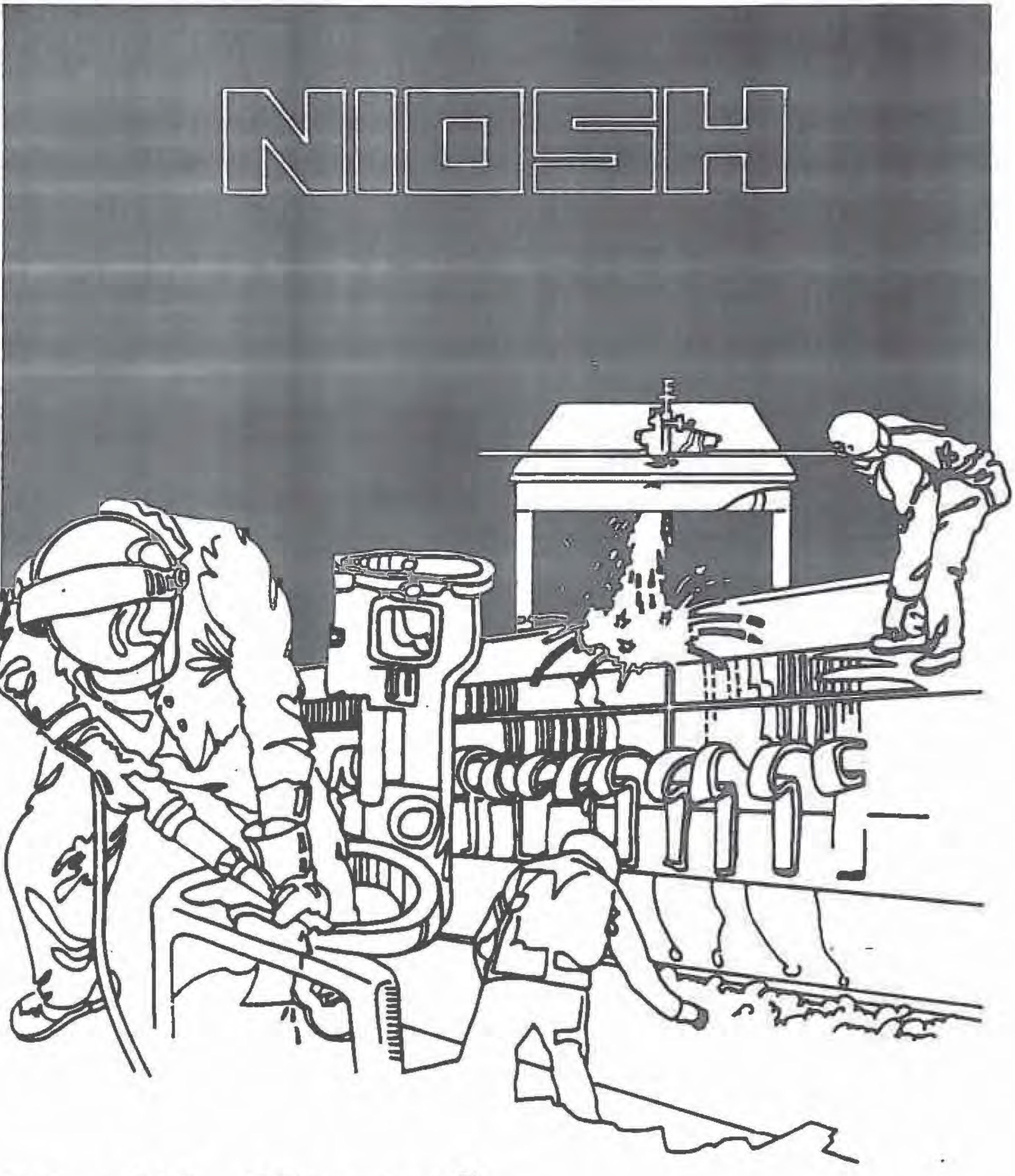

Health Hazard Evaluation Report

HETA 85-018-1759
AMERICAN CRYSTAL SUGAR CO.
MOORHEAD, MINNESOTA

PREFACE

The Hazard Evaluations and Technical Assistance Branch of NIOSH conducts field investigations of possible health hazards in the workplace. These investigations are conducted under the authority of Section 20(a)(6) of the Occupational Safety and Health Act of 1970, 29 U.S.C. 669(a)(6) which authorizes the Secretary of Health and Human Services, following a written request from any employer or authorized representative of employees, to determine whether any substance normally found in the place of employment has potentially toxic effects in such concentrations as used or found.

The Hazard Evaluations and Technical Assistance Branch also provides, upon request, medical, nursing, and industrial hygiene technical and consultative assistance (TA) to Federal, state, and local agencies; labor; industry and other groups or individuals to control occupational health hazards and to prevent related trauma and disease.

HETA 85-018-1759
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AMERICAN CRYSTAL SUGAR CO.
MOORHEAD, MINNESOTA

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I. SUMMARY

In October 1984, the National Institute for Occupational Safety and Health (NIOSH) received a request to evaluate occupational exposures to a number of substances used or generated in the processing of granulated sugar and other sugar products at the American Crystal Sugar Company's (ACSCo) plant in Moorhead, Minnesota. In addition, NIOSH was asked to evaluate employee exposures to welding fumes during ACSCo's summer maintenance operations.

On January 17 and 18, 1985, and on June 20 and 21, 1985, NIOSH industrial hygienists conducted environmental surveys at the plant, during beet processing activities and intercampaign (off-season) maintenance activities, respectively.

During the January 1985 survey, environmental air sampling was conducted to characterize employee exposures to amorphous silica, bischloromethyl ether (BCME), calcium carbonate, calcium oxide, coal dust, crystalline silica, fly ash, formaldehyde, hydrochloric acid (HCl), sugar beet pulp dust, and sugar dust. Settled dust and/or high volume (hi-vol) air samples were collected in areas where coke, limestone, pulp dust, coal and fly ash were present. Results were used to determine which of the personal air samples were to be analyzed for crystalline silica. Long-term general area air samples were collected for BCME and HCl.

Analysis of the air samples produced the following ranges of concentrations which are compared with their most stringent environmental criteria (EC): amorphous silica, 0.3 to 0.9 mg/M^3 (EC = 5.0 mg/M^3); calcium carbonate, 0.3 mg/M^3 (EC = 10 mg/M^3); calcium oxide, 1.0 to 3.4 mg/M^3 (EC = 2.0 mg/M^3); coal dust, 0.04 to 0.5 mg/M^3 (EC = 2.0 mg/M^3); fly ash, 0.2 to 0.6 mg/M^3 (EC = 5.0 mg/M^3); formaldehyde, 0.33 to 0.66 mg/M^3 (EC = lowest feasible level); hydrochloric acid, 0.03 to 0.20 mg/M^3 (EC = 7.0 mg/M^3); pulp dust, 0.2 to 0.5 mg/M^3 (EC = 5.0 mg/m^3); and sugar dust, 1.3 to 8.6 mg/M^3 (EC = 10.0 mg/M^3). Air samples for BCME and crystalline silica were nondetectable. Although crystalline silica was not detected in any of the personal air samples for pulp dust, its presence in both the hi-vol air and settled dust samples suggests that sugar beet pulp dust is not biologically inert, but rather that it can potentially produce silicosis in exposed workers. None of the exposures during the processing of sugar beets exceeded their respective OSHA standards.

During the June 1985, survey, full-shift, personal breathing-zone air samples were collected and analyzed for total welding fume, insoluble hexavalent chromium (Cr VI), and 26 specific elements of toxicological importance. Environmental concentration ranges for total welding fumes, insoluble Cr VI, and for those other metals present at concentrations greater than their respective most stringent EC are as follows: total welding fumes, 1.5 to 28 mg/M^3 (EC = 5.0 mg/M^3); copper fume, ND to 0.094 mg/M^3 (EC = 0.1 mg/M^3); iron oxide, 0.2 to 8.3 mg/M^3 (EC = 5.0 mg/M^3); and nickel, ND to 0.240 (EC = 0.015 mg/M^3). Both samples analyzed for insoluble Cr VI could not be quantified due to the presence of interfering metals in the samples. Other compounds or elements detected but at levels below their respective most stringent EC included aluminum oxide, barium, calcium oxide, total chromium, lead, manganese, magnesium oxide, and zinc oxide. No other elements were detected. Exposures for total welding fume and iron oxide were above their respective OSHA standards.

On the basis of the data obtained during this investigation it has been determined that workers at ACSCo's Moorhead plant were overexposed to calcium oxide and formaldehyde during sugar production activities and to total welding fumes, iron oxide, and nickel during intercampaign maintenance activities. Recommendations for reducing exposures and improving worker safety and health are presented in Section VIII of this report.

KEYWORDS: SIC 2063 (Beet Sugar) bischloromethyl ether, calcium carbonate, calcium oxide, sugar dust, welding fumes, hexavalent chromium, nickel, iron oxide, silica, pulp dust.

II. INTRODUCTION

On October 15, 1984, the National Institute for Occupational Safety and Health (NIOSH) received a joint request from the management of American Crystal Sugar Company (ACSCo) and the American Federation of Grain Millers International Union (AFGM), to evaluate employee exposures to several chemical substances used or generated in the processing of granulated sugar and other sugar products from sugar beets at all five sugar beet mills owned and operated by ACSCo. Additionally, NIOSH was requested to evaluate employee exposures to welding fumes generated during intercampaign (off-season) maintenance activities. This report covers the facility in Moorhead, Minnesota. The other four processing plants were located in Crookston, Minnesota (HETA 85-045), East Grand Forks, Minnesota (HETA 85-044), Drayton, North Dakota (HETA 85-046), and Hillsboro, North Dakota (HETA 85-043). Separate final reports have been prepared for the environmental surveys conducted in each of these plants.

On December 10 and 11, 1984, NIOSH investigators conducted a walk-through evaluation at the East Grand Forks and Crookston, Minnesota plants. The information obtained during the site visits at these plants was used to develop an air sampling protocol suitable for all five plants.

On January 17-18, 1985, NIOSH investigators conducted an industrial hygiene evaluation at the ACSCo plant in Moorhead, Minnesota to evaluate employee exposures to a variety of air contaminants during campaign (sugar processing) activities. In September 1985, an interim report which presented the environmental findings and preliminary recommendations of the January survey, was transmitted to all interested parties.

On June 20-21, 1985, a follow-up environmental survey was conducted to evaluate employee exposures to welding fumes during intercampaign maintenance activities. The results of the intercampaign welding survey were transmitted to all interested parties via letter in February 1986.

III. BACKGROUND

A. Plant Production and Workforce

The American Crystal Sugar Company (ACSCo) is a cooperative, owned by approximately 1700 sugar beet growers, with corporate offices in Moorhead, Minnesota. The company currently operates five sugar beet processing plants in the fertile Red River Valley situated along the Minnesota - North Dakota border.

The Moorhead facility was built in 1948 and employs approximately 690 workers. Production operations are run three shifts, seven days a week, throughout the 6 month beet slicing campaign period which lasts from about mid September to about mid March.

During the intercampaign period (off-season) approximately 300 of the 690 workers are retained on a one-shift 6-day schedule to repair and maintain equipment throughout the facility.

During the campaign the Moorhead plant processes nearly 4000 tons of sugar beets a day, which are grown on about 67,000 acres of land in 5 surrounding counties. On the average, approximately 595 tons of sugar are produced each day of the 180 day campaign period. The average daily output of beet molasses and beet pulp, the by-products of the refining process, approximates 219 tons and 278 tons, respectively.

B. Process Description

Beet sugar production, as indicated above, is a seasonal operation. In the early to late fall the beets are harvested and transported by truck to the plant where they are either stockpiled on the ground or dumped directly from the trucks into wet hoppers. Beets enter the factory via a water flume and go through several debris removing devices prior to washing. After cleaning, the beets are sliced into pieces called "cossettes". The cossettes are conveyed into the bottom of a large inclined cylindrical vessel called the diffuser. Hot water, flowing across the cossettes, is used to extract the sugar via osmosis. The sugar solution leaves the diffuser in the form of "raw juice". The processed cossettes (beet pulp), now devoid of most of the sugar, are dried in a large coal fired rotary drying drum, then are made into pellets for use as livestock feed.

After leaving the diffusers, the raw juice is mixed with milk of lime and carbon dioxide (CO_2) (produced in the lime kiln from the oxidation of $CaCo_3$ using coke as a fuel source) in carbonation vessels to precipitate impurities and non-sugars from the juice. The juice is filtered several times to remove solidified impurities. The "thin juice" as it is now called is piped into evaporators, which thicken the mixture by evaporating excess water. The steam required for the evaporation process is provided by coal-fired boilers. The resulting thickened juice is boiled in vacuum pans and seeded with sugar crystals to initiate the crystallization process. The mixture is then transferred to centrifugals where the sugar crystals are separated from the remaining syrup (beet molasses). After drying, the sugar crystals are sorted by crystal size through screens, and stored in bulk bins (concrete silos or Weibul bins) prior to being bagged or bulk loaded into railroad cars.

C. Potential Sources of Exposures

During the campaign period, workers were potentially exposed to a variety of airborne contaminants in various operations throughout the plant. A listing of the job classifications, potential contaminant exposures and their sources by area, is provided in Table 1.

During the intercampaign period maintenance workers were potentially exposed to metal fumes generated from welding operations. The type of welding techniques observed during the survey included shielded metal arc welding, carbon arc welding, air arc welding, and metal inert gas (MIG) welding on stainless, galvanized, and carbon steel. Plasma and oxyacetylene cutting were also performed.

IV. EVALUATION DESIGN AND METHOD

A. Campaign (Sugar Production)

On January 17 and 18, 1985, personal breathing zone and/or general area air samples were collected to characterize employee exposures to calcium oxide dust, calcium carbonate dust, pulp dust, coal dust, fly ash, crystalline silica, sugar dust, formaldehyde, hydrochloric acid (HCL), and bischloromethylether (BCME). Since several of the particulate materials being evaluated potentially contained crystalline silica, bulk samples and/or settled rafter dust samples were collected for qualitative and quantitative crystalline silica analyses. Additionally, total and respirable high volume (hi-vol) samples were collected in the pulp dryer and lime kiln areas. These samples were located in relatively dusty areas with the intent of obtaining sufficient dust loading on the filters to confirm the presence of silica polymorphs (i.e. quartz and cristobalite). The settled dust and hi-vol samples were analyzed prior to analysis of personal air samples. The settled dust samples collected for silica analysis included beet pulp dust, coal dust, fly ash, coke dust, limestone, and the filter aid products Dicalite® and Harborlite®. Results of these analyses were used to further determine which, if any, of the personal samples collected for the various dusts were to be analyzed for silica.

Air sampling and analytical methodologies for sampled substances, along with other pertinent data, are presented in Table 2. A discussion of the sampling strategies incorporated in the exposure assessment for each of these substances is provided below.

Lime kiln employees, including the lime kiln operator and the lime kiln helper, were monitored for exposure to calcium oxide dust. Exposure to calcium oxide was evaluated by collecting total dust samples from each worker and analyzing them for elemental calcium. Since both of these workers were potentially exposed to calcium oxide and calcium carbonate dust and since there is no practical method for distinguishing between these two compounds on a particular sample, exposures to calcium oxide or calcium carbonate were assigned based on the work area of the employee. Based on our observations, both employees worked in the vicinity of the lime kiln, an area where we feel calcium oxide dust was more prevalent. Accordingly, both workers were assigned exposures to calcium oxide. A respirable dust sample was also collected from the lime kiln operator for gravimetric analysis and crystalline silica analysis, as indicated from the bulk sample analysis.

Employees responsible for maintaining the coal-fired boilers and pulp dryers were monitored for exposure to coal dust or fly ash. Employees monitored included two boiler workers (coalman and ashman) and two pulp dryer workers (coalman and ashman). Because there is no practical method for distinguishing between coal dust and fly ash on a particular sample, results were classified as either coal dust or fly ash based upon the observed duties of the employee. All of these samples were held for crystalline silica analysis, pending the results of the bulk sample analysis.

Respirable dust samples were collected from workers potentially exposed to beet pulp dust. These included the pellet mill operator, the employee working in the pulp pellet bins, and the pellet loader. Further analysis of these samples for crystalline silica was dependent upon its presence in the settled rafter dust samples.

Total particulate samples were collected from employees potentially exposed to sugar dust, including sugar sackers at the new and the old sacking lines, the Weibul housekeepers, and the sugar-end maintenance mechanic. All samples were analyzed gravimetrically for sugar dust.

Operators of the juice filtration units were evaluated for exposure to respirable amorphous silica. Respirable dust samples were collected near the breathing zone of the U.S. filter operator and the Industrial filter operator during charging of the system to determine their exposure to amorphous silica contained in the Harborlite® and the Dicalite® filter aids, respectively.

Because formaldehyde and HCl are used in the sugar manufacturing process there was a concern that BCME, a recognized animal and human carcinogen, could be formed from the interaction of these two substances, especially since its presence has been documented by NIOSH investigators [1] in a similar sugar beet plant where formaldehyde and HCl were also used. To address this concern general area air samples were collected for HCl and BCME from areas or process equipment where formaldehyde and HCL were likely to be present. Due to a limited number of sampling media, general area air samples for formaldehyde were not obtained. Personal breathing zone air samples for formaldehyde were collected from the utility man who was responsible for charging the diffuser with paraformaldehyde. Personal breathing zone air samples were collected from three employees working in the carbonation area during the clean-out of the #1 evaporator with HCl.

B. Intercampaign (welding)

On June 20 and 21, 1985 workers were evaluated for exposure to welding fumes of various metals. The type of welding techniques observed during this survey included shielded metal arc welding, carbon arc welding, metal inert gas (MIG) welding, and air arc welding, on stainless, galvanized, and carbon steel. Plasma and oxyacetylene cutting were also performed. Air sampling and analytical methodologies for the sampled substances are presented in Table 2.

Filter cassettes were placed high on the collar of the welders to ensure their placement inside the welding helmet to provide an air sample indicative of what the workers would have been breathing since our experience has shown that concentrations are lower inside the welding helmet. For those workers welding on stainless steel preweighed filters were used to provide both total welding fume and insoluble hexavalent chromium levels. Since the specific metal constituents of the welding fume were unknown, inductively coupled plasma-atomic emission spectroscopy (ICP-AES), a technique which provides for the simultaneous analysis of a wide range of metals of toxicological importance, was used instead of atomic absorption spectroscopy. A list of the elements analyzed by ICP-AES are presented in the appendix.

V. EVALUATION CRITERIA

A. Environmental Evaluation Criteria

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

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

The primary sources of environmental evaluation criteria for the workplace are: 1) NIOSH Recommended Exposure Limits (REL's)[2], 2) the American Conference of Governmental Industrial Hygienists' (ACGIH) Threshold Limit Values (TLV's)[3], and 3) the U.S. Department of Labor/Occupational Safety and Health Administration (OSHA) occupational health standards[4]. Often, the NIOSH REL's and ACGIH TLV's are lower than the corresponding OSHA standards. Both NIOSH REL's and ACGIH TLV's usually are based on more recent information than are the OSHA standards. The OSHA standards also may be required to take into account the feasibility of controlling exposures in various industries where the agents are used; the NIOSH REL's, by contrast, are based primarily on concerns relating to the prevention of occupational disease. In evaluating the exposure levels and the recommendations for reducing these levels found in this report, it should be noted that industry is required by the Occupational Safety and Health Act of 1970 (29 USC 651, et seq.) to meet those levels specified by an OSHA standard.

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

A list of the sampled substances included in these evaluations and their applicable environmental criteria are provided in Table 3, along with a brief description of their primary health effects. For those substances which were found to be in excess of their most stringent environmental criteria the following discussion is presented.

B. Health Effects of Specific Compounds

1. Calcium oxide[5,6]

Calcium oxide (lime dust) irritates the eyes and upper respiratory tract. The irritant effects are probably due primarily to its alkalinity, but dehydrating and thermal effects also may be contributing factors. Inflammation of the respiratory passages, ulceration and perforation of the nasal septum, and pneumonia have been attributed to inhalation of calcium oxide dust; severe irritation of the upper respiratory tract ordinarily causes persons to avoid serious inhalation exposure. Particles of calcium oxide have caused severe burns of the eyes; prolonged or repeated contact with the skin could cause dermatitis.

2. Formaldehyde[5,7]

The health effects of formaldehyde can result from acute or chronic exposure. The effects of acute exposure are primarily mucous membrane irritation (burning, tearing eyes; nose and throat irritation). These symptoms can occur as low as about 0.1 parts per million (ppm). Dermatitis associated with formaldehyde vapor, solution or formaldehyde-containing resins has been documented. Formaldehyde is a primary skin irritant but may also cause allergic dermatitis at concentrations below those likely to cause primary effects.

Allergic effects include skin sensitization and possibly asthma or asthma-like symptoms. There is considerable evidence that formaldehyde can produce skin sensitization in man, especially in persons occupationally exposed through skin contact. Eczematous contact dermatitis, when acute, is characterized by swelling, vesiculation and oozing with itching. In the chronic form, affected areas of the skin may become dry, thickened and fissured.

A recent study conducted by the Chemical Industry Institute of Toxicology, in which rats and mice exposed to formaldehyde vapors developed nasal cancer, has raised concern about its carcinogenic potential in humans.

3. Total Welding fumes, not otherwise classified[3,6]

The health effects associated with exposure to welding fumes is dependant on the toxicity of individual component metals. This classification applies to welding environments where concentrations of toxic metals (i.e., chromium, cadmium, zinc) are not in excess of their respective exposure criteria. Usually in these situations the major component of the fume is iron oxide or aluminum oxide, depending on whether the base metal is carbon (mild) steel or aluminum. Oxides of these metals are considered nuisance particulates based on their $5 mg/M^3$ criteria.

4. Iron oxide fume[5,6]

Inhalation of iron oxide fume or dust causes an apparently benign pneumoconiosis termed siderosis. Iron oxide alone does not cause fibrosis in the lungs of animals, and the same probably applies to humans. Exposures of 6 to 10 years are usually considered necessary before changes recognizable by x-ray can occur; the retained dust gives x-ray shadows that may be indistinguishable from fibrotic pneumoconiosis. Eight of 25 welders exposed chiefly to iron oxide for an average of 18.7 (range 3 to 32) years had reticulonodular shadows on chest x-rays consistent with siderosis but no reduction in pulmonary function; exposure levels ranged from 0.65 to $47 mg/M^3$. In another study, 16 welders with an average exposure of 17.1 (range 7 to 30 years also had x-rays suggesting siderosis and spirograms which were normal; however, the static and functional compliance of the lungs was reduced; some of the welders were smokers. The welders with the lowest compliance complained of dyspnea.

5. Nickel [5,8]

Metallic nickel and certain soluble nickel compounds as dust or fume cause sensitization dermatitis and probable produce cancer of the paranasal sinuses and the lung; nickel fume in high concentrations is a respiratory irritant. Severe but transient pneumonitis in two workers resulted from exposure to nickel fume; in one cause, exposure was for six hours, and post-incident sampling suggested a nickel concentration of 0.26 mg/M^3. "Nickel itch" is a dermatitis resulting from sensitization to nickel; the first symptom is usually itching, which occurs up to seven days before skin eruption appears. The primary skin eruption is erythematous, or follicular; it may be followed by superficial discrete ulcers, which discharge and become crusted, or by eczema; in the chronic stages, pigmented or depigmented plaques may be formed. Nickel sensitivity, once acquired, is apparently not lost; recovery from the dermatitis usually occurs within seven days of cessation of exposure, but may take several weeks. A worker who had developed cutaneous sensitization also developed apparent asthma from inhalation of nickel sulfate; immunologic studies showed circulating antibodies to the salt, and controlled exposure to a solution of nickel sulfate resulted in decreased pulmonary function and progressive dyspnea; the possibility of developing hypersensitivity pneumonitis could not be excluded. In animals, finely divided metallic nickel was carcinogenic when introduced into the pleural cavity, muscle tissue, and subcutaneous tissues; rats and guinea pigs exposed to a concentration of 15 mg/M^3 of powdered metallic nickel developed malignant neoplasms. Several epidemiologic studies have shown an increased incidence of cancer of the paranasal sinuses and lungs among workers in nickel refineries and factories; suspicion of carcinogencity has been focused primarily on respirable particles of nickel, nickel subsulfide, nickel oxide, and on nickel carbonyl vapor.

VI. RESULTS AND DISCUSSION

A. Campaign (Sugar Production)

1. Bulk samples, settled rafter dust samples, and hi-vol air samples

Table 4 presents the results of the crystalline silica analyses for the bulk dust and settled rafter dust samples. Quartz was detected in the samples of pulp dust and fly ash at concentrations of 7.4% and 1.9% by weight, respectively. Neither of these samples contained detectable quantities of cristobalite (less than 0.75%, by weight). The results of the crystalline silica analysis on coal dust and coke dust bulk samples showed trace quantities of quartz between the analytical limit of detection (LOD) and the analytical limit of quantitation (LOQ). These quantities are considered to be semi-quantitative data. Cristobalite was not detected in any of these samples. Quartz and cristobalite were not detected in bulk samples of limestone or either of the filter aids Dicalite® and Harborlite®.

Table 5 presents the results of hi-vol general area air samples for respirable and total particulates and crystalline silica (% quartz). Samples were collected in the vicinity of the pulp dryer and the lime kiln. Results show that airborne quartz was detected in both respirable and total air samples collected at the pulp dryer. Respirable air samples collected in the lime kiln pit showed trace quantities of quartz between the LOD and the LOQ. Cristobalite was not detected in any of these samples.

2. Personal Breathing Zone and General Area Air Samples

Environmental sampling results for each of the sampled substances are presented in Tables 6-14, along with the applicable environmental criteria.

Air sampling results for calcium carbonate, calcium oxide and respirable particulates are presented in Table 6. Calcium oxide exposures of the lime kiln operator and the lime kiln helper ranged from 1.0 to 3.4 mg/M^3. Although exposures did not exceed the Occupational Safety and Health Administration's (OSHA) PEL of 5.0 mg/M^3, both employees had exposures exceeding the American Conference of Governmental Industrial Hygienists (ACGIH) TLV of 2.0 mg/M^3 for calcium oxide. Calcium carbonate exposures of the rock shovel operator were 0.3 mg/M^3 both days of sampling and were far below the ACGIH TLV of 10 mg/M^3. A respirable dust sample collected from the lime kiln operator revealed a particulate exposure concentration of 1.0 mg/M^3, the ACGIH-TLV and the OSHA PEL are 5.0 mg/M^3. Since crystalline silica was not detected in the bulk samples of limestone and coke, further analysis of this respirable sample for crystalline silica was not indicated.

Air sampling results for coal dust, fly ash, and quartz are presented in Table 7. Coal dust exposures of the boiler coalman and the pulp dryer coalman ranged from 0.04 to 0.5 mg/M^3 and were below the ACGIH TLV of 2.0 mg/M^3 and OSHA PEL of 2.4 mg/M^3. Fly ash exposures of the boiler coalman and the pulp dryer coalman ranged from 0.2 to 0.6 mg/M^3 and were all below the ACGIH TLV and OSHA PEL of 5.0 mg/M^3.

Results of the personal samples collected for respirable sugar beet pulp dust are presented in Table 8. Pulp dust concentrations ranged from 0.2 to 0.5 mg/M^3. Because crystalline silica was detected in the settled rafter dust sample, the personal samples were analyzed for crystalline silica. All four samples were non-detectable (less than 0.015 mg/sample), therefore, the respirable dust concentrations are compared to the ACGIH TLV and OSHA PEL of 5.0 mg/M^3 for respirable nuisance dust. Although crystalline silica was not detected in these samples, its presence in all of the settled rafter dust samples and in the hi-vol air samples suggests that the pulp dust is not an inert dust. Rather, we feel that pulp dust should be regarded as a material which can potentially cause silicosis in exposed workers.

Sugar dust air sample results are presented in Table 9. Airborne concentrations measured in personal samples ranged from 1.3 to 8.6 mg/M^3 and were highest for the Weibul housekeeper. None of the personal samples exceeded the ACGIH TLV of 10 mg/M^3 or the OSHA PEL of 15 mg/M^3.

Respirable amorphous silica sample results are presented in Table 10. The U.S. filter operator had exposures of 0.6 and 0.9 mg/M^3 and the Industrial filter operator had exposures of 0.3 and 0.4 mg/M^3. Since bulk samples of Harborlite® and Dicalite® did not contain detectable levels of quartz or cristobalite, these concentrations are compared to the ACGIH TLV or OSHA PEL of 5.0 mg/M^3 for nuisance dust.

Table 11 presents the results of the personal breathing zone air sampling for formaldehyde. Formaldehyde was detected in two samples collected from the utility man who was responsible for charging the diffuser with paraformaldehyde, typically using 6 bags per day.

Results showed concentrations of 0.33 and 0.66 mg/M^3. These levels by comparison, were below the ACGIH TLV of 1.2 mg/M^3 and the OSHA PEL of 3.7 mg/M^3, as an 8-hour TWA. However, NIOSH recommends that exposures be reduced to the lowest feasible level since formaldehyde is considered by NIOSH to be a suspect human carcinogen.

Table 12 presents the personal breathing zone air sample results for hydrochloric acid (HCl) which were collected during a routine boil out of residue from the inside of the #1 evaporator. Personal samples ranged from 0.03 mg/M^3 to 0.20 mg/M^3 during the approximately 3 to 4 hour operation and are below the environmental exposure criteria of 7 mg/M^3.

Table 13 gives the sample results of area sampling for HCl and BCME. HCl and BCME samples were coupled in two areas, both samples showed low levels of HCl and non-detectable levels of BCME. Additionally, an area sample for BCME collected during the boil out of the #1 evaporator showed non-detectable levels. Due to a limited number of sampling media for formaldehyde, general area air samples for formaldehyde were not collected.

B. Intercampaign (welding)

Air sampling results from the June 1985 welding survey are presented in Table 14. Environmental concentrations are provided for total welding fumes, iron oxide, and for those other metals which were present at concentrations greater than 50% of their respective (most stringent) occupational exposure limits. Other elements which were detected but at levels no higher than this "action level" are identified in this Table 13, along with those elements which were nondetectable.

Airborne concentrations of total welding fumes ranged from 1.5 to 28 mg/M^3, with 10 of 15 air samples exceeding the OSHA PEL of 5.0 mg/M^3. Specific metals or compounds measured at concentrations above their respective action level included copper, iron oxide, and nickel. Copper concentrations ranged from nondetectable to 0.094 mg/M^3. None of the samples exceeded the OSHA PEL of 0.1 mg/M^3. Iron oxide concentrations ranged from 0.2 to 8.3 mg/M^3. Two samples exceeded the OSHA PEL of 5.0 mg/M^3. Nickel concentrations ranged from ND to 0.240 mg/m^3. Six of 16 samples exceeded the NIOSH REL of 0.015 mg/M^3, while none exceeded the OSHA PEL of 1.0 mg/M^3. Two samples analyzed for insoluble hexavalent chromium (Cr VI) could not be quantified because of interferences (excessive levels of other metals) present in the samples.

Other elements or compounds which were detected at levels below their action level include: aluminum oxide, barium, calcium oxide, chromium (total), lead, magnesium oxide, manganese, and zinc oxide. The following elements were evaluated but not detected in any samples: arsenic, beryllium, boron, cadmium, cobalt, lanthanum, platinum, selenium, silver, strontium, tellurium, thallium, vanadium, yttrium, and zirconium.

VII. DISCUSSION AND CONCLUSIONS

A. Campaign (Sugar Production)

The environmental sampling results presented in this report show that lime kiln workers were overexposed to calcium oxide dust and that workers in the diffuser area were overexposed to formaldehyde.

Observations of workers in the lime kiln area revealed that particulate exposures resulted primarily from sweeping/shoveling of dusts which had accumulated on the floors. The heaviest accumulations were observed below open-track conveyor systems. We feel that these conveyor systems should be either automated and/or enclosed to minimize dust levels. More complete containment of the transported materials should help reduce housekeeping requirements and resulting exposures associated with these activities. Until implementation of these control measures, we recommend that workers involved in cleanup activities wear appropriate respiratory protection. If possible, vacuuming instead of dry sweeping techniques should be utilized.

Air sampling results for formaldehyde indicate that this compound is released into the plant environment following its introduction to the diffuser. Although the airborne levels (0.33 and 0.66 mg/M^3) did not exceed the ACGIH TLV or OSHA PEL, they do represent a potential carcinogenic risk to exposed workers. Therefore, the possibility of substituting formaldehyde with a bacteriocide that is less toxic should be investigated. If this is not feasible efforts should be directed toward reducing exposures to the lowest feasible level by implementation of engineering and/or administrative controls, with respiratory protection being used as an interim control measure.

Sugar dust samples collected from the Weibul housekeeper did not exceed the applicable environmental criteria but did approach these levels indicating that the cleaning activities generated considerable airborne sugar dust. This was due, in part, to the fact that these workers used dry sweeping methods to remove sugar dust from various surfaces. Although dry sweeping may be more convenient, we recommend that the central vacuum system be used as much as possible to reduce exposures. In areas not serviced by the central vacuum system, portable vacuum systems should be used, where practical. Additionally, appropriate respirators should be used in situations where visible airborne dust is observed in the sugar bins.

Although respirable dust samples collected from workers exposed to pulp dust did not document silica exposures, the presence of silica in the high volume general area samples and the settled rafter dust samples shows that pulp dust does contain silica. Therefore, appropriate precautions should be taken.

B. Intercampaign (Welding)

The results of the environmental sampling indicate that 67% of the welders were overexposed to airborne concentrations of total welding fumes. The highest exposures to welding fumes were measured in samples obtained from workers welding inside the diffuser, a confined space work environment. All six samples collected from employees working inside the diffuser showed excessive concentrations of total welding fumes and nickel and two of the six showed excessive concentrations of iron oxide. Excessive exposures to nickel are of particular concern since this substance has been associated with the development of nasal and/or lung cancer in humans.

The two samples collected from employees working inside the diffuser which were analyzed for the presence of Cr VI could not be quantified because of the presence of interferences in the sample. Not much welding was being done on stainless steel but, based on the sample results from the other plants, it would be reasonable to expect that the samples collected for Cr VI would have been above the NIOSH REL for Cr VI, especially in light of the fact that the other plants had utilized portable welding fume exhausters whereas the Moorhead facility did not.

Based on the data collected at the other facilities, we concluded that these devices provided adequate air movement to prevent or, at the very least, significantly lower employee exposures to total welding fume and other welding fumes when properly used. Additionally, none of the workers were observed wearing respiratory protection. Welders working in non-confined work settings throughout the plant did not use local exhaust ventilation (LEV) systems nor did they use respirators to protect themselves from generated contaminants.

The extent of the welding fume exposures (approximately two-thirds of the personal samples exceeded the most stringent occupational exposure criteria for total welding fumes), and the fact that potential human carcinogens were present in all samples collected on employees working inside the diffuser underlie the need for effective control measures to minimize worker exposure.

VIII. RECOMMENDATIONS

In view of the environmental findings the following recommendations (provided to the company and union in the interim reports) were made to ameliorate existing or potential hazards, and to provide a better work environment for ACSCo employees. These recommendations primarily involve implementation of engineering controls such as automation, redesign, replacement and/or repair of existing equipment and ventilation systems or a combination of these measures.

1. Efforts to reduce particulate exposures in the lime kiln should be directed toward automating or enclosing the conveyor systems. More complete containment of the transported material should help reduce housekeeping requirements and associated exposures. Until these control measures are implemented, we recommend that workers involved in clean-up activities remove settled dust by vacuuming instead of dry sweeping, and also wear appropriate respiratory protection.

2. Although we did not detect crystalline silica in the air samples obtained from workers exposed to pulp dust, the presence of crystalline silica in the settled rafter dust samples and the hi-vol air samples underlies the need for improvements to the dust collection systems servicing the pulp/pellet conveyors. Reducing dust emissions from these conveyors should significantly reduce the housekeeping requirements in the pellet mill and the exposures associated with cleaning activities.

3. Although dry sweeping may be more convenient, the central vacuum system should be used as much as possible by the Weibul housekeeping crew to reduce exposures to sugar dust. In areas not serviced by the central vacuum system, a portable vacuum system should be used, where practicable. Additionally, appropriate respirators should be used in situations where visible airborne dust is observed in the sugar bins.

4. The company should investigate the possibility of substituting formaldehyde with a bacteriocide that is less toxic. If this is not feasible, efforts should be directed toward reducing formaldehyde exposures to the lowest feasible level by implementation of engineering and/or administrative controls, with respiratory protection being used an an interim control measure.

5. Portable local exhaust ventilation (LEV) systems similar to those used at the other facilities should be purchased and employees should be instructed in the proper use of these devices.

6. Portable LEV systems should be used when welding or cutting in confined spaces. In non-confined work areas, particularly when working with stainless steel, a primary source of carcinogenic hexavalent chromium, nickel, and other toxic metals LEV systems should be used. When using LEV systems, the hood (typically the end of the duct) should be placed as close as practical to the arc site. Provisions should be made to ensure that welding fumes of toxic metals are not exhausted into an area where other workers are present. Additionally, make-up air for confined spaces where LEV systems are used should be clean. Reevaluation of welding fume exposures should be conducted following implementation or modification of ventilation controls.

7. In situations where the use of LEV systems are impractical, workers should be provided with appropriate respiratory protection. Supplied air respirators are required in confined spaces in the absence of sufficient contaminant removal and make-up air[4]. This type of respirator should also be used when welding on stainless steel in non-confined work spaces where use of an LEV system is impractical. Powered air purifying helmets and half-mask respirators with high efficiency particulate filters would be effective for carbon steel welding fumes provided that gaseous co-contaminants are not present in high concentrations.

8. Those workers welding for prolonged periods of time in one location should use a fan or welding fume exhauster to prevent fumes from entering his/her breathing zone. Welding curtains should be used as much as possible to minimize ultraviolet (UV) radiation exposure of other workers in the area.

9. Since welding and other fume-producing operations are routinely done in the machine shop, exhaust ventilation should be used to remove fumes. Ideally, freely moveable fume hoods with flexible ducting should be used which would allow the welder to position the hood as close as practical to the work being welded.

10. Workers using the air arc welder or needle gun (as well as other workers in the immediate vicinity of these operations) should always wear proper hearing protection.

11. All welding (and cutting) operations should comply with the requirements outlined in the General Industry Occupational Safety and Health Standards, OSHA (29 CFR 1910.252).

12. Use of respirators in situations where engineering controls are impractical may require modification and/or expansion of the existing respiratory protection program. All aspects of this program must comply with the requirements provided in 29 CFR 1910.134.

13. Workers using oxyacetylene cutting torches should always wear tinted lenses. Appropriate shade numbers of lenses for specific operations are provided in 29 CFR 1910.252 (e) 2(i).

14. The company should conduct periodic air sampling for those substances where overexposures were documented to assure that the extent of implementation of the above recommendations are adequate to protect the affected workers.

15. The company should conduct periodic medical monitoring of welders. Monitoring should include a symptoms history, chest exam, and pulmonary function testing.

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XI. DISTRIBUTION AND AVAILABILITY OF DETERMINATION REPORT

Copies of this Determination Report are currently available upon request from NIOSH, Division of Standards Development and Technology Transfer, Resources and Dissemination Section, 4676 Columbia Parkway, Cincinnati, Ohio 45226. After 90 days the report will be available through the National Technical Information Services (NTIS), Port Royal Road, Springfield, Virginia 22161. Information regarding its availability through NTIS can be obtained from NIOSH publications office at the Cincinnati address. Copies of this report have been sent to the following:

1. American Crystal Sugar Company, Moorhead Plant
2. American Crystal Sugar Company, Corporate Office
3. American Federation of Grain Millers, Minneapolis, Minnesota
4. American Federation of Grain Millers, Local #266
5. U.S. Department of Labor, OSHA - Region V

For the purposes of informing the affected employees, copies of the report should be posted in a prominent place accessible to the employees, for a period of 30 calendar days.

Table 1

Potential Exposures during Campaign (Sugar Processing)

American Crystal Sugar Company
Moorhead, Minnesota
HETA 85-018

January 17-18, 1985

Location	Job Classifications of Monitored Workers	Potential Contaminant(s)	Source(s) of Contaminants
Lime kiln/limestone stockpile	Lime kiln operator, lime kiln helper, rock shovel operator	Calcium oxide, calcium carbonate	CaO is produced in the lime kiln from oxidation of calcium carbonate; generated primarily from open track conveyor system at base of lime kiln. CO is incomplete combustion product from conversion of $CaCO_3$ to CaO.
Diffuser and carbonation area	Utility man, stationary air samples	Formaldehyde, hydrochloric acid, bischloromethyl ether	Formaldehyde, piped into the diffusers to control bacteria, may be present as a vapor at the discharge pulp conveyor at the top of the diffusers. Dilute hydrochloric acid is used to manually clean drum filters. BCME is not used at plant but may be formed from interaction of HCl and formaldehyde[9]
Pulp pellet mills	Pellet mill operator, mechanic, and loaders	Beet pulp dust, crystalline silica	Pellet machines, pellet transfer equipment such as conveyors, front end loaders; housekeeping activities.
Boiler and pulp dryer areas	Coal and ash handlers	Coal dust, fly ash crystalline silica	Unloading of coal from rail cars, maintenance and housekeeping activities.
Carbonation area	U.S. filter and industrial filter operators	Amorphous silica	Manual bag changing of Harborlite® and Dicalite® into receiving hoppers.
Sugar silos/bins; sugar sacking stations	Sugar bin cleaners and operators; and sackers	Sugar dust (total)	Loading sugar into rail cars, bagging sugar, housekeeping activities.

Table 2

Sampling and Analysis Methodology

American Crystal Sugar Company
Moorhead, Minnesota
HETA 85-018

Substance	Collection Media	Flowrate (LPM)	Analysis	Detection Limit (ug/sample)	NIOSH Reference Method[10,11]
		CAMPAIGN			
Amorphous silica (respirable)	PVC filter with 10 mm cyclone	1.7	Gravimetric	0.01	0600
Bischloromethyl ETHER (BCME)	Impinger containing 15 ml 2,4,6-trichlorophenol	0.6	Gas chromatography	0.002	P&CAM 220
Calcium	AA filter	1.5	Atomic absorption	2	7020
Coal dust (respirable)	PVC filter with 10 mm cyclone	2.0	Gravimetric	0.01	0600
Fly ash (respirable)	PVC filter with 10 mm cyclone	1.7	Gravimetric	0.01	0600
Formaldehyde	Solid sorbent tube	0.080	Gas chromatography	2	2502
Free silica (respirable)	PVC filter with 10 mm cyclone	1.7	X-ray diffraction	15	7500
Hydrochloric acid (HCL)	Solid sorbent tube	0.5	Ion chromatography	2	7903
Sugar beet pulp dust (respirable)	PVC filter with 10 mm cyclone	1.7	Gravimetric	0.01	0600
Sugar dust	PVC filter	1.5	Gravimetric	0.01	0500
		INTERCAMPAIGN			
Chromium, hexavalent (insoluble)	PVC filter	1.2	Visible spectroscopy	0.2	7600
Metals	FWSB filter	1.2	ICP-AES	See Appendix	7300
Welding fume	PVC filter	1.0	Gravimetric	0.01	0500

Table 3

Evaluation Criteria and Health Effects Summary

American Crystal Sugar Company
Moorhead, Minnesota
HETA 85-018

Substance	Evaluation Criteria[1] (mg/M3)			Primary Health Effects	References
	NIOSH REL	OSHA PEL	ACGIH TLV		
Amorphous silica	-	5.0	5.0	Amorphous silica has been shown to cause fibrosis and significantly decreased lung function in monkeys.	3,4,12
Bischloromethylether (BCME)	lowest feasible level	regulated carcinogen	0.005	Associated with an increased incidence of lung cancer in humans, highly carcinogenic in rodents.	2,3,4
Calcium carbonate (limestone) dust	-	15.0	10.0	Considered a nuisance particulate. Excessive concentrations of nuisance particulate may cause unpleasant deposits in the eyes, ears, and nasal passages, and may seriously reduce workroom visibility.	3,4
Calcium oxide dust (total)	-	5.0	2.0	Causes irritation of the eyes, mucous membranes, and skin. Dust inhalation may cause ulceration and perforation of nasal system.	3,4,5
Chromium, hexavalent (insoluble)	0.001	0.5	0.05	Lung cancer, skin ulcers and lung irritation.	2,3,4,13
Coal dust (< 5% quartz)	-	2.4	2.0	Coal workers pneumoconiosis.	3,5
Coal dust (> 5% quartz)	-	Crystalline silica formula			
Copper fume	---	0.1	0.2	Irritation of the upper respiratory tract, metal fume fever.	3,4,5
Crystalline silica (respirable)	0.05	$\frac{10 \text{ mg/M3}}{\% \text{ SiO}_2+2}$	$\frac{10 \text{ mg/M3}}{\% \text{ SiO}_2+2}$	Silicosis; a pneumoconiosis due to the inhalation of silicon dioxide-containing dust, which is a disabling, progressive and sometimes fatal pulmonary fibrosis characterized by the presence of typical nodulation in the lungs.	2,3,14

(Table 3 continued on next page)

Table 3 (continued)

Substance	Evaluation Criteria[1] (mg/M3)			Primary Health Effects	References
	NIOSH REL	OSHA PEL	ACGIH TLV		
Fly ash[2]	-	5.0	5.0	Regulated as a nuisance particulate. When crystalline silica content in bulk samples is less than 1%. Excessive concentrations of nuisance dusts may cause unpleasant deposits in the eyes, ears, and nasal passages, and may seriously reduce workroom visibility.	2,3
Formaldehyde	lowest level feasible	3.7 (3.0 ppm)	1.2(c) (1.0 ppm)	Vapors can cause irritation of the eyes & upper respiratory tract. Animal carcinogen. Contact with the liquid can cause both primary irritation and sensitization dermatitis.	2,3,7
Hydrochloric acid (HCL)	7.0 5 ppm	7.0 5 ppm	7.0(c) 5 ppm	A strong irritant of the eyes, mucous membranes, and skin.	2,3,15
Iron oxide (as Fe)	---	5.0	5.0 (10.0 STEL)	Siderosis - a benign pneumoconiosis or respiratory condition associated with inhalation of particulates.	2,3,15
Nickel, inorganic (as Ni)[3]	0.015	1.0	1.0	Respiratory irritation from fume, skin effects; lung and nasal cancer.	2,3,4
Sugar beet pulp dust (respirable)[2]	-	5.0	5.0	Regulated as a nuisance particulate. Refer to health effects described for fly ash.	3,9
Sugar dust (Total)	-	15.0	10.0	Same as above.	
Welding fumes (N.O.C.)	-	5.0	5.0	Toxicity of component metal must be considered individually.	3,4

1. Values represent time-weighted average (TWA) exposure limits for up to a 10 hour workday unless otherwise specified.
2. Nuisance dust classification is based on presence of less than 1% quartz in dust sample. If greater than 1% quartz crystalline silica formula must be used.
3. OSHA nickel standard is given for the metal and soluble compounds as Ni.

Abbreviations: (c) Ceiling limit exposures shall not exceed this concentration.
(STEL) - short-term exposure limit, considered a maximum concentration not to be exceeded at any time during a 15 minute sample period.
(N.O.C.) - Not otherwise classified.

Table 4

Crystalline Silica Content in Bulk and Settled Rafter Dust Samples

American Crystal Sugar Company
Moorhead, Minnesota
HETA 85-018

January 17-18, 1985

Substance	Crystalline silica (% by wt.)	
	Quartz	Cristobalite
Beet pulp dust - rafter	7.4	<0.75
Coal dust - boilerhouse	(1.0)	<0.75
" " - pulp dryer	(1.0)	<0.75
Fly ash - boilerhouse	1.9	<0.75
Limestone	<0.75	<0.75
Coke	(1.5)	<0.75
Dicalite© (amorphous silica)	<0.75	<0.75
Harborlite© (amorphous silica)	<0.75	<0.75

Laboratory limit of detection (0.75% by weight)
Laboratory limit of quantitation (1.5% by weight)

( ) = Trace quantities were detected, values fall between the limit of detection (LOD) and the limit of quantitation (LOQ) and are considered semi-quantitative estimates. They are not quantitative data.

Table 5

High Volume Air Samples for Total and Respirable Crystalline Silica

American Crystal Sugar Company
Moorhead, Minnesota
HETA 85-018

January 17-18, 1985

Location	sample time (minutes)	sample vol. (liters)	particulates (mg/M^3)	Quartz (mg/M^3)	% Quartz
January 17					
Pulp dryer, south end (Resp.)	470	4089	0.76	0.007	1.0 *
Pulp dryer, south end (Total)	470	4136	1.46	0.019	1.3 *
January 18					
Lime kiln - pit (Resp.)	129	1122	4.14	(0.018)	(0.4)*
Lime kiln - pit (Total)	129	1135	71.24	<0.75%	<0.75%*

* Cristobalite was not detected
(   ) Trace quantities detected, values fall between the LOD and the LOQ and are considered semi-quantitative estimates. They are not quantitative data.

Table 6

Calcium Oxide and/or Calcium Carbonate exposures of worker
associated with the Lime Kiln

American Crystal Sugar Company
Moorhead, Minnesota
HETA 85-018

January 17-18, 1985

Date	Job/Location	sample time (minutes)	sample volume (liters)	Airborne Concentration (mg/M^3) Calcium Carbonate	Calcium Oxide	Respirable Particulates
1/17/85	Rock shovel operator	496	744	0.3	--	--
1/18/85	Rock shovel operator	410	615	0.3	--	--
1/17/85	Lime kiln operator	496	744	--	1.0	--
1/18/85	Lime kiln operator	498	747	--	3.4	--
1/18/85	Lime kiln operator	499	998	--	--	1.0
1/17/85	Lime kiln helper	461	692	--	2.2	--
1/18/85	Lime kiln helper	468	702	--	1.5	--
Environmental Criteria:			ACGIH-TLV	10.0	2.0	5.0
			OSHA-PEL	15.0	5.0	5.0

Exposures to calcium carbonate ($CaCO_3$) or calcium oxide (CaO) were assigned to workers based on location; e.g. workers in the vicinity of the lime kiln-calcium oxide, those elsewhere calcium carbonate.

Abbreviations:
mg/M^3 - milligrams of CaO or $CaCO_3$ per cubic meter of air

Table 7

Respirable Coal Dust and Fly Ash exposures of Boiler and Pulp Dryer Workers

American Crystal Sugar Company
Moorhead, Minnesota
HETA 85-018

January 17-18, 1985

				Airborne Concentrations (mg/M³)		
Date	Job/Location	sample time (minutes)	sample vol. (liters)	Coal Dust	Fly Ash	Quartz
1/17/85	Boiler - coal man	510	1020	0.4	--	NA
1/18/85	Boiler - coal man	518	1036	0.5	--	NA
1/17/85	Boiler - ash man	492	836	--	0.4	NA
1/18/85	Boiler - ash man	502	853	--	0.6	NA
1/17/85	Pulp dryer - coal man	486	972	0.04	--	NA
1/18/85	Pulp dryer - coal man	490	980	0.1	--	NA
1/17/85	Pulp dryer - ash man	501	852	--	0.2	NA
1/18/85	Pulp dryer - ash man	484	823	--	0.2	NA
Environmental Criteria:		NIOSH		--	--	0.05
		ACGIH-TLV		2.0	5.0	0.10
		OSHA-PEL		2.4	5.0	--

Abbreviations:

ND - Not Detected; less than 0.015 mg per sample.
NA - Not Analyzed; quartz in these samples would have been non-detectable since the other samples of higher particulate loading were non-detectable.
mg/M³ - milligrams of contaminant per cubic meter of air

Table 8

Personal Breathing Zone Air Concentrations of Respirable Pulp Dust & Crystalline Silica

American Crystal Sugar Company
Moorhead, Minnesota
HETA 85-018

January 17-18, 1985

Date	Job/Location	sample time (minutes)	sample volume (liters)	Airborne Concentrations (mg/M^3)	
				Pulp dust	Quartz
1/17/85	Pulp pellet bins	494	840	0.2	ND
1/17/85	Pellet loading shed	485	824	0.5	ND
1/17/85	Pellet mill operator	466	792	0.4	ND
1/18/85	Pellet mill operator	500	850	0.3	ND
Environmental Criteria:		NIOSH		--	0.05
		ACGIH-TLV		5.0*	0.10
		OSHA-PEL		5.0*	--

* Although crystalline silica was not present in the personal air samples its presence in the bulk samples and the high volume general area air samples for total and respirable particulates suggest that pulp dust is not biologically inert but rather a substance that could potentially produce silicosis in exposed workers.

Abbreviations:
ND - Not Detected; less than 0.015 mg per sample.
mg/M^3 - milligrams of contaminant per cubic meter of air

Table 9

Personal Breathing Zone Air Concentrations of Sugar Dust

American Crystal Sugar Company
Moorhead, Minnesota
HETA 85-018

January 17-18, 1985

Date	Job/Location	sample time (minutes)	sample volume (liters)		Sugar dust Airborne concentration mg/M^3
1/17/85	Sugar sacker (new line)	492	738		1.9
1/18/85	Sugar sacker (new line)	502	753		1.3
1/17/85	Sugar sacker (old line)	486	729		3.6
1/18/85	Sugar sacker (old line)	490	735		3.4
1/17/85	Weibul housekeeper	486	729		8.6
1/18/85	Weibul housekeeper	480	720		5.2
1/17/85	Sugar-end maintenance mechanic	499	748		1.4
1/18/85	Sugar-end maintenance mechanic	504	756		4.1
Environmental Criteria:				ACGIH-TLV	10.0
				OSHA-PEL	15.0

Abbreviations:
mg/M^3 - milligrams of sugar dust per cubic meter of air

Tab[illegible]10

Respirable Amorphous Silica Exposures of Filter Operators

American Crystal Sugar Company
Moorhead, Minnesota
HETA 85-018

January 17-18, 1985

Date	Job/Location	sample time (minutes)	sample volume (liters)	Airborne concentration Amorphous silica* (mg/M^3)
1/17/85	US filters charged Harborlite® and Dicalite®	507	862	0.6
1/17/85	Industrial filters Dicalite®	512	870	0.3
1/18/85	US filters charged Harborlite®	505	858	0.9
1/18/85	Industrial filters Dicalite®	494	840	0.4
Environmental Criteria:			NIOSH	--
			ACGIH-TLV	5.0
			OSHA-PEL	5.0

* Amorphous silica is the major component of both Harborlite® and Dicalite® filter aids. Since the analysis was gravimetric (i.e., not specific for amorphous silica) values should be considered a maximum concentration.

Abbreviations:
mg/M^3 - milligrams of contaminant per cubic meter of air

Table 11

Personal Breathing Zone Air Concentrations of Formaldehyde

American Crystal Sugar Company
Moorhead, Minnesota
HETA 85-018

January 17-18, 1985

Date	Job/Location	sample time (minutes)	sample volume (liters)	Airborne Concentration	
				(mg/M^3)	(ppm)
1/17/85	Utility man charged 6 bags paraformaldehyde	512	39.8	0.33	0.27
1/18/85	Utility man charged 6 bags paraformaldehyde	504	39.2	0.66	0.54
Environmental Criteria:			NIOSH	Lowest Feasible Limit	
			ACGIH-TLV	1.2	1.0
			OSHA-PEL	3.7	3.0

NIOSH and ACGIH consider formaldehyde a potential human carcinogen.
Abbreviations: ppm - parts of formaldehyde per million parts of air

Table 12

Personal Breathing Zone Air Concentrations of Hydrochloric Acid

American Crystal Sugar Company
Moorhead, Minnesota
HETA 85-018

January 17-18, 1985

Date	Job/Location	sample time (minutes)	sample volume (liters)	HCl Airborne Concentration (mg/M^3)
1/17/85	Pan floor helper, north end wore respirator part-time	227	114	0.20
1/17/85	Granulator and crystallizer operator	185	92	0.11
1/17/85	Centifuge operator	181	90	0.03
Environmental Criteria:			NIOSH	7
			ACGIH-TLV	7-ceiling
			OSHA-PEL	7-ceiling

Table 13

General Area Air Concentrations of Formaldehyde, Hydrochloric acid (HCl) and Bischloromethyl ether (BCME)

American Crystal Sugar Company
Moorhead, Minnesota
HETA 85-018

January 17-18, 1985

Date	Location	sample time (minutes)		Airborne Concentrations (mg/M^3) Formaldehyde	HCl	BCME
1/17/85	At beet washer	298		*	0.05	ND
1/17/85	At picking table	410		*	0.03	ND
1/17/85	Pan floor, #1 evaporator	238		*	*	ND
Environmental Criteria:			NIOSH	LFL	7	LFL
			ACGIH-TLV	1.2	7(c)	0.005
			OSHA-PEL	3.7	7(c)	Regulated Carcinogen

Abbreviations:
LFL - Lowest Feasible Level
c - ceiling limit

* simulataneous sampling for formaldehyde and/or HCl were not conducted due to limited sampling media.

NIOSH and ACGIH consider formaldehyde a potential human carcinogen.
NIOSH, OSHA, and ACGIH regard BCME a confirmed human carcinogen.

Table 14

Personal Air Sampling Results for Welding Fumes
American Crystal Sugar Company
Moorhead, Minnesota
HETA 85-018

June 20-21, 1985

Date	Location/Job	Sampling† Duration	Sample Volume (liters)	Environmental Concentration (mg/M^3) Total Welding Fume	Hexavalent Chromium	Copper Fume	Iron Oxide	Nickel
6-20	Lime kiln, replacing outer wall	0709-1524	491*	12	NA			
			786			0.005	1.9	0.002
6-21	" " " " "	0700-1503	485	5.7	NA			
			679			0.016	2.5	0.003
6-21	" " " " "	0706-1503	431	3.7	NA			
			647			0.008	1.5	ND
6-20	Inside diffuser, repairing flights	0710-1515	351	5.4	NA			
			526			0.034	1.6	0.018
6-21	" " " "	0701-1433	278	13	NA			
			445			0.049	2.9	0.067
6-20	" " " "	0713-1503	423	13	**			
			677			0.072	5.5	0.083
6-21	" " " "	0702-1427	338	28	**			
			541			0.094	8.3	0.240
6-21	" " " "	0703-1446	301	11	NA			
			503			0.070	3.6	0.040
6-21	" " " "	0705-1455	433	7.1	NA			
			649			0.040	2.5	0.059

(Table 14 continued on next page)

(Table 1[illegible] continued)

Date	Location/Job	Sampling† Duration	Sample Volume (liters)	Environmental Concentration (mg/M^3)				
				Total Welding Fume	Hexavalent Chromium	Copper Fume	Iron Oxide	Nickel
6-20	Juice heaters, installing new heads	0737-1519	381	4.4	NA			
			610			0.006	0.8	0.002
6-21	" " " " "	0707-1334	312	1.9	NA			
		0707-1112	392			0.006	1.4	0.003
		1112-1334	107			ND	0.4	ND
6-20	" " " " "	0740-1527	301	7.6	NA			
			452			0.006	1.2	ND
6-21	" " " " "	0715-1509	364	2.1	NA			
			564			0.011	0.5	0.003
6-20	" " , building new heads	0708-1404	416	7.2	NA			
			582			0.027	1.4	ND
6-20	Outside repairing wet hopper	0739-1511	380	1.5	NA			
			608			ND	0.2	ND
Environmental Criteria:		NIOSH		---	0.001	---	---	0.015
		ACGIH		5.0	0.05	0.2	5.0	1.0
		OSHA		5.0	0.5	0.1	5.0	1.0

ND - not detected, less than analytical limit of detection.
NA - not analyzed because welding was not done on stainless steel, a primary source of hexavalent chromium.
† - The pumps on-time was used to calculate sample volumes. Sampling duration time indicated may have been interrupted by breaks or a restricted flow conditions (e.g., a pinched hose).
* - filter damaged by welding sparks
** - quantitation of hexavalent chromium not possible due to interferences

NOTE: Other elements or compounds which were detected but did not exceed 50% of their respective (most stringent) environmental exposure limits include: aluminum oxide, barium, calcium oxide, chromium (total), lead, magnesium oxide, manganese, and zinc oxide.

The following elements were not detected in any samples: arsenic, beryllium, boron, cadmium, cobalt, lanthanum, platinum, selenium, silver, strontium, tellurium, thallium, vanadium, yttrium, and zirconium.

APPENDIX

Elements Analyzed by ICP-AES and Their Corresponding Analytical Limits of Detection

American Crystal Sugar Company
Moorhead, Minnesota
HETA 85-018

Element	Analytical Limit of Detection (micrograms per sample)
Aluminum	10
Arsenic	5.0
Boron	10
Barium	1.0
Beryllium	1.0
Calcium	5.0
Cadmium	1.0
Cobalt	1.0
Chromium	1.0
Copper	1.0
Iron	1.0
Lanthanum	2.5
Magnesium	1.0
Manganese	1.0
Nickel	1.0
Lead	2.5
Platinum	5.0
Selenium	5.0
Silver	2.5
Tellurium	10
Titanium	10
Thallium	10
Vanadium	1.0
Yttrium	1.0
Zinc	1.0
Zirconium	10

Note: 1000 micrograms = 1 milligram