U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES ■ Public Health Service
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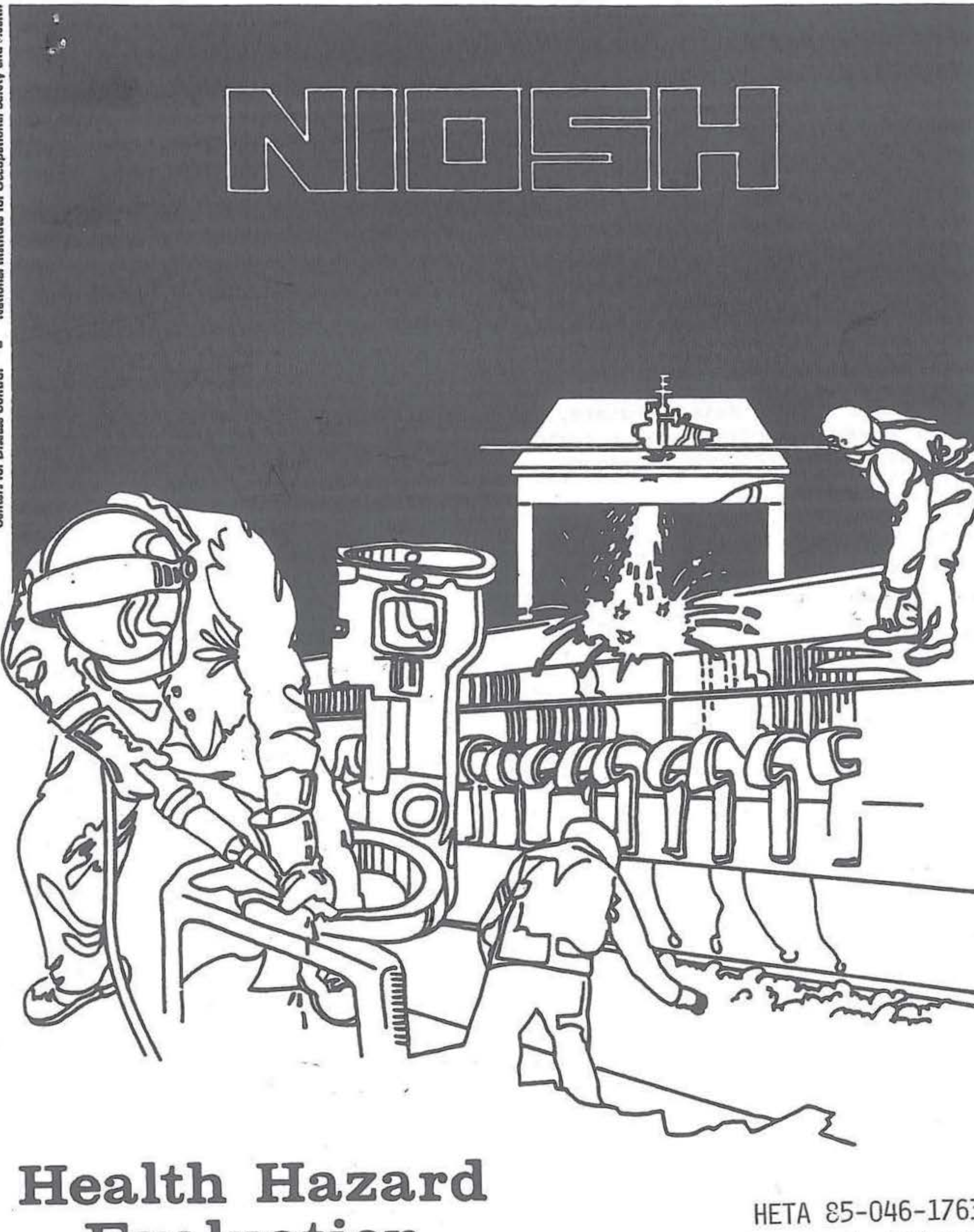

Health Hazard Evaluation Report

HETA 85-046-1763
AMERICAN CRYSTAL SUGAR COMPANY
EAST GRAND FORKS, 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 85-046-1763
DECEMBER 1986
AMERICAN CRYSTAL SUGAR COMPANY
EAST GRAND FORKS, 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 East Grand Forks, Minnesota. In addition, NIOSH was asked to evaluate employee exposures to welding fumes during ACSCo's summer maintenance operations.

On February 1 and 2, 1985, and on May 22 and 23, 1985, NIOSH industrial hygienists conducted environmental surveys at the plant, during beet processing activities and off-season maintenance activities, respectively.

During the February survey, full-shift personal breathing-zone air sampling was conducted to characterize employee exposure to amorphous silica, bischloromethyl ether (BCME), calcium carbonate, calcium oxide, carbon monoxide (CO), coal dust, crystalline silica, fly ash, formaldehyde, hydrochloric acid (HCl), sugar beet pulp dust, and sugar dust. Settled dust and/or high volume 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, HCl, and formaldehyde.

Analysis of the air samples produced the following ranges of concentrations which are compared with their most stringent environmental criteria (EC): amorphous silica, 0.1 to 0.6 mg/M^3 (EC = 5.0 mg/M^3); calcium carbonate, 11.2 mg/M^3 (one sample) (EC = 10.0 mg/M^3); calcium oxide, 5.2 to 9.3 mg/M^3 (EC = 2.0 mg/M^3); carbon monoxide, 3 to 12 ppm (EC = 35 ppm); coal dust, 0.3 to 0.6 mg/M^3 (EC = 2.0 mg/M^3); fly ash, 0.3 to 2.4 mg/M^3 (EC = 5.0 mg/M^3); pulp dust, 0.3 to 0.7 mg/M^3 (EC = 5.0 mg/m^3); and sugar dust, 1.4 to 13 mg/M^3 (EC = 10.0 mg/M^3). Air samples for BCME, HCl, formaldehyde, 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 bulk 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. Calcium oxide and sugar dust were only substances exceeding their respective OSHA standards.

During the May 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, Cr VI, and for those other metals present at concentrations greater than their respective most stringent EC are as follows: total welding fumes, 0.6 to 5.5 mg/M^3 (EC = 5.0 mg/M^3); insoluble Cr VI, ND to 0.013 mg/M^3 (EC = 0.001 mg/m^3), and nickel, ND to 0.11 (EC = 0.015 mg/M^3). Other compounds or elements detected but at levels below their respective most stringent EC included aluminum oxide, barium, calcium oxide, total chromium, copper, iron oxide, manganese, magnesium, and zinc oxide. No other elements were detected. The only OSHA standard exceeded was that for total welding fumes.

On the basis of the data obtained during this investigation, it has been determined that workers at ACSCo's East Grand Forks plant were overexposed to calcium oxide, calcium carbonate, and sugar dust during sugar production activities, and to total welding fumes, insoluble hexavalent chromium, 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) calcium carbonate, calium oxide, sugar dust, welding fumes, hexavalent chromium, nickel, iron oxide, silica, pulp dust, BCME.

II. INTRODUCTION

In October 1984, the National Institute for Occupational Safety and Health (NIOSH) received a joint request from the management of the American Crystal Sugar Company (ACSCo) and the American Federation of Grain Millers International Union (AFGM) to evaluate employee exposures to chemical substances used or generated in the processing of granulated sugar and other sugar products from sugar beets in all five of ACSCo's processing plants. Additionally, NIOSH was requested to evaluate employee exposures to welding fumes generated during off-seasonal (intercampaign) maintenance activities. This report covers the facility in East Grand Forks, Minnesota. The other four processing plants were located in Crookston (HETA 85-045) and Moorhead (HETA 85-018), Minnesota, and in Drayton (HETA 85-044) and Hillsboro (HETA 85-043), North Dakota. Separate final reports have been prepared for the environmental surveys conducted in each of these plants.

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

On February 1 and 2, 1985, we evaluated employee exposures to a variety of air contaminants during campaign (sugar processing) activities at the East Grand Forks facility. Environmental findings and recommendations from this survey were provided to the company and union, in two interim reports, issued in March and August 1985.

On May 21 to 23, 1985, we returned to the facility during intercampaign maintenance activities and evaluated worker exposures to welding fumes. The environmental findings and recommendations from this survey were presented to the company and union via two interim letters, issued in June and December 1985.

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 East Grand Forks facility, built in 1926 and later expanded in 1974, is the oldest and largest of the five plants. The plant employs 680 workers and operates on three shifts, seven days a week, throughout the 6 month beet slicing campaign period which lasts from about mid-September to March. During the off-season approximately 210 of the 680 workers are retained on a one-shift 6-day schedule to repair and maintain equipment throughout the facility.

During the campaign, the East Grand Forks plant processes nearly 6800 tons of sugar beets a day, which are grown on about 60,000 acres of land in 5 surrounding counties. On the average, approximately 970 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, appproximates 340 and 400 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 grounds 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 long noodle-like pieces called "cossettes". The cossettes are conveyed into the bottom of a large vertical 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, and are made into pellets for use as livestock feed.

After leaving the vertical 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 impuritites. 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, approximately 10 to 15 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 and metal inert gas (MIG) welding on stainless, galvanized, and carbon steel. Apart from welding, an evaluation was made of machine shop employees, who used the Rototec® metal coating sprayer, to assess their exposure to metal particulates generated during the process.

IV. EVALUATION DESIGN AND METHODS

A. Campaign (Sugar Production)

On February 1 and 2, 1985, personal and/or general area air samples were collected to characterize employee exposures to airborne concentrations of calcium oxide dust, calcium carbonate (limestone) dust, pulp dust, crystalline silica, coal dust, fly ash, sugar dust, amorphous silica, formaldehyde, hydrochloric acid (HCL), and bischloromethylether (BCME). Since most of the particulate materials under investigation potentially contained crystalline silica, we collected settled rafter dust samples and respirable high volume (hi-vol) air samples for qualitative and quantitative crystalline silica analyses. The settled dust samples collected for silica analysis included limestone, beet pulp, coke, coal, and fly ash. The respirable hi-vol air samples were collected from the pellet mill, 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 silica polymorphs (i.e., quartz and cristobalite) present. The settled dust and hi-vol air samples were analyzed prior to analysis of the personal air samples. Results of these analysis were used to determine which, if any, of the personal samples for dusts were to be analyzed for crystalline 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 used in assessing exposures to each of these substances is provided below.

Lime kiln workers (i.e. slaker operator, limestone/coke mill person, lime kiln foreman) were monitored for exposure to carbon monoxide (CO), calcium oxide, calcium carbonate, respirable particulates, and crystalline silica.

A total of six air samples for CO were collected from each of the lime kiln workers. Additionally, stationary CO air samples were collected in the vicinity of the CO gas blower and washer.

One total dust sample was collected from each worker and analyzed for elemental calcium. Because there is no practical method for distinguishing between calcium carbonate and calcium oxide on a particular sample, exposures were assigned based upon the work area of the employee. Based on our observations, the slaker operator and lime kiln foreman, who both worked in the vicinity of the lime kiln, were assigned exposure to calcium oxide. The limerock/coke mill person was assigned exposure to calcium carbonate. One respirable dust sample was also collected from each worker for gravimetric and crystalline silica analysis, if indicated from results of the bulk sample and/or hi-vol sample analyses.

Employees responsible for maintaining the coal-fired boilers and pulp dryers were monitored for exposure to coal dust and fly ash. Four workers were monitored, including a coal handler and an ashman for each of the boilers and the pulp dryers. Two respirable dust samples were collected from each worker each day for a total of eight air samples. Because there is no practical method for distinguishing between coal dust and fly ash on a particular sample, results are classified as either coal dust or fly ash exposures dependent on the job title of the employee. All eight samples were held for crystalline silica analysis, pending the results of the bulk samples.

Respirable dust samples were collected from workers potentially exposed to beet pulp dust. These included the pellet mill operator, mechanic, and loaders. Two, one, and four air samples, respectively, were collected from these workers and analyzed gravimetrically for pulp dust. Further analysis of these samples for crystalline silica was dependent on whether it was present in the bulk or hi-vol air samples.

Nine total dust samples were collected from workers potentially exposed to sugar dust. These included four samples from the sugar baggers, two each from the bin operator and bulk loader, and one from the bin cleaner. All samples were analyzed gravimetrically for sugar dust.

Operators of juice filtration units were evaluated for exposure to respirable amorphous silica. Two samples each were collected from the Industrial filter operator and the Carbonation filter operator during bag charging of Harborlite® and Dicalite®, respectively, into mixing hoppers.

Because formaldehyde and HCl are used in the sugar manufacturing process, there was 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 we collected general area air samples for each of these substances from three areas in the plant, near the process equipment where HCl and formaldehyde were likely to be present. These included the diffuser, drum filter, and screen house.

B. Intercampaign (Welding)

On May 22 and 23, 1985, twenty 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 and metal inert gast (MIG) welding on stainless, galvanized, and carbon steel. In addition to welding fumes, we also evaluated particulate emissions from the Rototec® metal coating spray process, at the request of several machine shop employees. Air sampling and analytical methodologies for the sampled substances are presented in Table 2.

In order to evaluate the welders' exposures, the filter cassettes were placed high on the collar to ensure their placement inside the welding helmet which would provide an air sample indicative of what the worker is breathing, since our experience has shown that concentrations are lower inside the helmet. For those workers welding on stainless steel preweighted filters were used to provide both total welding fume and insoluble hexavalent chromium levels. Since the specific metal constituents of the welding fume and metal spray 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 levels 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 (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 use; 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 legally required 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 this evaluation 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 skin could cause dermatitis.

2. Calcium carbonate and sugar dust[3]

Available toxicity data indicate that of these substances would be categorized as "nuisance" dusts. Nuisance dusts, in contrast to fibrogenic dusts which cause scar tissue to be formed in the lungs when inhaled in excessive amounts, have a long history of little adverse effect on the lungs. They do not produce significant organic disease or toxic effect when exposures are kept under reasonable control. The nuisance dusts have also been called (biologically) "inert" dusts, but the latter term is inappropriate to the extent that there is no dust which does not evoke some cellular response in the lung, when inhaled in sufficient amount.

Excessive concentrations of nuisance dust in the workroom air may seriously reduce visibility; may cause unpleasant deposits in the eyes, ears, and nasal passages; or cause injury to the skin or mucous membranes by chemical or mechanical action per se or from the rigorous skin cleaning procedures necessary for their removal.

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 nusiance particulates based on their 5 mg/M^3 criteria.

In this particular evaluation, nickel and hexavalent chromium (Cr VI) were found to be present at concentrations in excess of their exposure criteria in most of the air samples obtained from welders.

4. Chromium [5,7]

Chromium compounds can act as allergens in some workers to cause dermatitis to exposed skin. Acute exposure to chromium dust and mist may cause irritation of the eyes, nose and throat. Chromium exists in chromates in one of three valence states 2+, 3+, and 6+. Chromium compounds in the 3+ state are of a low order of toxicity. In the 6+ state, chromium compounds are irritants and corrosive. This hexavalent form may be carcinogenic or non-carcinogenic depending on solubility. The less-soluble forms are carcinogenic. Workers in the chromate-producing industry have been reported to have an increase risk of lung cancer. The known health hazards from excessive exposure to chromium welding fumes are dermatitis, ulceration and perforation of the nasal septum, irritation of the mucous membranes of the larynx, pharynx, conjuctiva and chronic asthmatic bronchitis.

5. Nickel [5,8]

Metallic nickel and certain soluble nickel compounds as dust or fume cause sensitization dermatitis and probably 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 with 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 carcinogenicity has been focused primarily on respirable particles of nickel, nickel subsulfide, nickel oxide, and on nickel carbonyl vapor.

VI. RESULTS

A. Campaign (Sugar Production)

1. Settled rafter dust samples and hi-vol air samples for crystalline silica

Table 4 presents the results of the crystalline silica analysis of the settled rafter dust samples. Quartz was detected in samples of pulp dust, coal dust and fly ash. Concentrations ranged from 2.6 to 11%, by weight. The highest quartz content was found in three samples of pulp dust, ranging from 9.3 to 11%, by weight. None of these samples contained detectable concentrations of cristobalite (less than 0.75%, by weight). Quartz and cristobalite were not detected in samples of limestone or coke (less than 0.75% for both analytes).

Results of the hi-vol air samples for crystalline silica are presented in Table 5. Results show that airborne quartz was detected in two to three areas where sampling was conducted. In the areas where pulp dust was present (pellet mill and pulp dryer samples) the quartz content of respirable dust samples was approximately 3%, by weight. No cristobalite was detected in these two samples.

The hi-vol air sample obtained from the lime kiln area did not contain detectable quantities of quartz or cristobalite (less than 0.015 mg per sample for both polymorphs).

2. Personal and General Area Air Samples

Environmental sampling results are presented in Tables 6-12, along with applicable environmental criteria.

Air sampling results for calcium oxide, calcium carbonate, and respirable particulates are presented in Table 6. Calcium oxide exposures of the slaker operator and lime kiln foreman were measured at 5.2 and 9.3 mg/M^3, respectively, and exceeded both the OSHA Permissible Exposure Limit (PEL) of 5.0 mg/M^3 and the more stringent ACGIH Threshold Limit Value (TLV) of 2.0 mg/M^3. One air sample collected from the limestone/coke mill person revealed a concentration of 11 mg/M^3 to calcium carbonate. This concentration, by comparison, did not exceed the OSHA PEL of 15 mg/M^3, although it did exceed the ACGIH TLV of 10 mg/M^3. Respirable dust samples collected from these same workers showed concentrations varying from 1.3 to 2.9 mg/M^3. Since crystalline silica was not detected in the settled rafter dust sample or the hi-vol air sample, further analysis of these samples for silica was not indicated. The measured respirable dust levels are therefore comparable to the nuisance dust criterion of 5.0 mg/M^3.

Samples for carbon monoxide (CO) obtained from lime the kiln workers are presented in Table 7. CO exposures of the lime kiln foreman, slaker operator, and the limestone/coke handler ranged from 3 to 13 ppm. These levels were below the NIOSH Recommended Exposure Limit (REL) of 35 ppm and the less stringent OSHA standard of 50 ppm. Two area samples taken at the gas blower and gas washer measured 35 and 10 ppm, respectively. The level of CO at the gas blower suggests that this equipment was probably leaking and a potential source of exposure for workers in this area.

Air sampling results for coal dust, fly ash, and crystalline silica are presented in Table 8. Coal dust exposures of the boiler and pulp dryer coalmen ranged from 0.3 to 0.6 mg/M^3, and were all below the OSHA PEL of 2.4 mg/M^3 and the ACGIH TLV of 2.0 mg/M^3. Fly ash exposures of the boiler and pulp dryer ashmen ranged from 0.3 to 2.4 mg/M^3. These levels by comparison, were below the ACGIH TLV and OSHA PEL of 5.0 mg/M^3 for nuisance dust. Coal dust and fly ash exposures were generally higher for the pulp dryer workers than the boiler workers. Based on the fact that crystalline silica was detected in the bulk samples of coal dust and fly ash, the personal samples were also analyzed for silica. Six of the 8 samples, representing those with the highest dust loading from each exposure group, were analyzed. Quartz was not detected in any of these samples (less than 0.015 mg per sample). Therefore, the remaining two samples were not analyzed.

Results of the personal air samples for respirable pulp dust are presented in Table 9. Because crystalline silica was found in both the settled rafter dust samples and in the hi-vol air samples, the personal air samples were submitted for crystalline silica analysis. Of the seven air samples, 4 with the highest particulate loading were analyzed first. None of these samples contained detectable quantities of quartz (less than 0.015 mg per sample). Consequently, the remaining three samples were not analyzed. Airborne concentrations of pulp dust ranged from 0.3 to 0.7 mg/M^3. 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 sampling results are presented in Table 10. Airborne concentrations for the nine personal samples ranged from 1.4 to 13 mg/M^3. One sample, obtained from the sugar bin operator, exceeded the ACGIH TLV of 10 mg/M^3 but was within the OSHA PEL of 15 mg/M^3.

Respirable amorphous silica exposure results are presented in Table 11. Concentrations ranged from 0.1 to 0.6 mg/M^3. Because the analysis was gravimetric and not specific for amorphous silica, these levels should be considered a maximum. None of the samples exceeded the ACGIH TLV or the OSHA PEL of 5.0 mg/M^3 for amorphous silica.

Table 12 presents the results for formaldehyde, HCl, and BCME. None of these substances were detected in any of the air samples.

B. Intercampaign (Welding)

Air sampling results are presented in Table 13. 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 Table 13, along with those elements which were nondetectable. Separate discussions of the welding and the Rototec® spray metal coating air sampling results will be provided since these are fundamentally different processes.

1. Welding Operations - airborne concentrations of total welding fumes ranged from 0.6 to 5.5 mg/M^3, with 1 of 20 air samples exceeding the OSHA PEL of 5.0 mg/M^3. Specific metals or compounds measured at concentrations above their respective action level, apart from iron oxide, included insoluble hexavalent chromium (Cr VI) and nickel. Concentrations of insoluble Cr VI ranged from nondetectable (ND) to 0.013 mg/M^3. Nine of 17 samples exceeded the NIOSH REL of 0.001 mg/M^3, while none exceeded the OSHA PEL of 0.5 mg/M^3. Nickel concentrations ranged from ND to 0.11 mg/m^3. Four of 20 air samples exceeded the NIOSH REL of 0.015 mg/M^3, while none exceeded the OSHA PEL of 1.0 mg/M^3. Iron oxide concentrations ranged from 0.1 to 2.1 mg/M^3. None of these samples exceeded the OSHA PEL of 5.0 mg/M^3. Compounds or elements detected at levels below their action level included aluminum oxide, barium, calcium oxide, total chromium, copper, manganese, magnesium and zinc oxide. All of the other analyzed elements were nondetectable.

2. Metal-Coating Spray Process - air sampling results obtained from the Rototec® spray gun operator and a neighboring worker "downstream" from the flame revealed total particulate levels of 2.1 and 3.5 mg/M^3, respectively, during the 45-50 minute operation, (see Table 13). Major metals identified in the air samples included total chromium, iron oxide, and nickel. Concentrations ranged up to 0.1, 0.4 and 0.6 mg/M^3, respectively. Total chromium and iron oxide levels were below their respective exposure limits. Nickel concentrations, however, exceeded the NIOSH REL of 0.015 mg/M^3 but not OSHA's PEL of 1.0 mg/M^3.

VII. DISCUSSION AND CONCLUSIONS

A. Campaign (Sugar Production)

The environmental sampling results show that lime kiln workers were overexposed to calcium oxide and calcium carbonate, and that sugar bin workers were overexposed to sugar dust.

Particulate calcium oxide exposures in the lime kiln area appeared to be due in part to sweeping/shoveling of dust which had accumulated along the conveyor system below the lime kiln and along the limestone/coke conveyors. An open track conveyor is used to convey the calcium oxide to the slaker and, because of its inherent design, there is an ample opportunity for dust to fall through the conveyor tracks and onto the floor. Dust accumulations observed along the limestone/coke belt conveyors indicated that deficiencies existed in these systems as well.

The sugar dust sampling results show that one of the Weibul bin operators was overexposed to sugar dust while his counterparts involved in bagging, cleaning, and bulk loading operations had somewhat less exposure.

BCME formation appears to be unlikely considering the fact that both HCl and formaldehyde emissions were well controlled, and also due the fact that the drum filters and diffusers were not near one another.

B. Intercampaign (Welding)

The results of the environmental sampling indicate that welders were overexposed to airborne concentrations of insoluble hexavalent chromium, nickel, and in one case, to total welding fumes, and that workers involved with the metal Rototec® coating spray operation were overexposed to airborne concentrations of nickel. Overexposures to insoluble hexavalent chromium and nickel are of particular concern since these two substances have been associated with the development of nasal and/or lung cancer in humans.

The highest exposure to insoluble hexavalent chromium was measured in samples obtained from workers welding on stainless steel inside the diffuser, a confined space work environment. Although portable welding fume exhausters were used by the diffuser crew, the usefulness of these devices was limited to some degree when operated in the configuration we observed (i.e., using the intake of the fan as the hood with the flexible ducting on the discharge side of the fan), particularly since the fan had to be secured in place, often times no closer than several feet from the arc site. This situation allowed the welding fumes to enter the worker's breathing zone. None of the workers were observed wearing respiratory protection. The remaining workers who welded in non-confined work settings throughout the plant (including the machine shop) neither used contaminant removal systems nor respirators to protect themselves from generated contaminants.

Results of the two air samples collected during Rototec® metal coating spray operation revealed that both the sprayer and a neighboring worker were overexposed to nickel. In some cases exposures to some of the other major metals were higher for the worker downstream from the spray than that of the sprayer. It should be noted that the nature of the emissions may vary depending on the type of coating used.

The extent of the welding fume exposures (approximately two-thirds of the personal samples exceeded the most stringent occupational exposure criteria for nickel, hexavalent chromium, or total welding fumes), and the fact that potential human carcinogens were present in most of the samples underlie the need for effective control measures to minimize worker exposure.

VIII. RECOMMENDATIONS

In view of the findings of the environmental evaluations, the following recommendations (provided to the company and union in the interim reports) are 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 exposures associated with housekeeping activites. 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. Based on the sugar dust sampling results, employees working the sugar bins should continue to wear appropriate respiratory protection to minimize dust exposures especially in situations where visible airborne dust is present. Although exposures of the sugar bulk loaders and baggers were within acceptable exposure guidelines, exposures could be further reduced by utilizing vacuum methods to remove sugar dust accumulations on floors, and railroad cars, instead of dry sweeping and/or pressurized air.

3. 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 in the hi-vol 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.

4. An industrial ventilation consultant should be contacted to determine the effectiveness of the expanded ventilation system in the pellet mill area.

5. The gas blower and washers should be periodically checked to verify that CO levels are within acceptable limits.

6. The portable fume exhauster used by the diffuser welding crew should be modified so that it can be positioned as close as possible to the arc site. Specifically, the ducting should be attached to the intake side of the fan, using the end of the hose as the hood, with the fan being located outside of the diffuser. This modification will make it easier to locate the hood near the arc site.

7. Portable local exhaust ventilation (LEV) systems such as the type used by the diffuser crew should be used when welding or cutting in (other) 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 practicable to the arc site 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.

8. 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.

9. 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).

10. 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.

11. Metal coating operations conducted in the machine shop should be locally exhausted to prevent fumes from entering the worker's breathing zone. Ideally, a system with freely moveable hoods and flexible ducting should be used.

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

13. 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.

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

IX. References

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XI. DISTRIBUTION AND AVAILABILITY OF REPORT

Copies of this report are currently available upon request from NIOSH, Division of Standards Development and Technology Transfer, Publications Dissemination Section, 4676 Columbia Parkway, Cincinnati, Ohio 45226. After 90 days, the report will be available through the National Technical Information Service (NTIS), 5285 Port Royal, 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:

1. American Crystal Sugar Company, East Grand Forks Plant
2. American Crystal Sugar Company, Corporate Office
3. American Federation of Grain Millers, Minneapolis, Minnesota
4. American Federation of Grain Millers, Local 264
5. OSHA, Region V

For the purpose of informing affected employees, copies of this report shall be posted by the employer 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
East Grand Forks, Minnesota
HETA 85-046

February 1-2, 1985

Location	Job Classifications of Monitored Workers	Potential Contaminant(s)	Source(s) of Contaminants
Limestone/coke stockpiles	Coke/limestone handler	Coke, calcium carbonate crystalline silica	Coke and limerock conveyors, front end loader.
Lime kiln	Lime kiln foreman, slaker operator	Calcium oxide, carbon monoxide	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, screen house and carbonation areas	Stationary air sampling (no workers monitored)	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 hydroclorlc 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 activites.
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	Filter operator	Amorphous silica	Manual bag changing of Harborlite® and Dicalite® into receiving hoppers.
Sugar storage bins; sugar bagging and loading areas	Sugar bin cleaners and operators; bulk loaders and baggers	Sugar dust	Loading sugar into rail cars, bagging sugar, housekeeping activities.

TABLE 2

Sampling and Analysis Methodology

American Crystal Sugar Company
East Grand Forks, Minnesota
HETA 85-046

Substance	Collection Device	Flowrate (Lpm)	Sampling Duration Range (hrs)	Analysis	Detection Limit (ug/sample)	Reference Method 10,11
			CAMPAIGN			
Amorphous silica (respirable)	PVC filter with 10mm cyclone	1.7	7.8 → 8.0	Gravimetric	0.01	0600
Bischloromethyl ether (BCME)	Impinger containing 15 mls 2,4,6-trichlorp phenol	0.6	5.9 → 7.0	Gas chromatography	0.002	P&CAM 220
Calcium	AA filter	1.5	8.1	Atomic absorption	2	7020
Carbon monoxide	Draeger long-term indicator tube	0.020	6.1 → 8.3	Visual	-	-
Coal dust (respirable)	PVC filter with 10mm cyclone	2.0	4.0 → 8.5	Gravimetric	0.01	0600
Fly ash (respirable)	PVC filter with 10mm cyclone	1.7	6.4 → 8.5	Gravimetric	0.01	0600
Formaldehyde	Solid sorbent tube	0.080	5.9 → 7.0	Gas chromatography	2	2502
Free silica (respirable)	PVC filter with 10mm cyclone	1.7	4.0 → 8.5	X-ray diffraction	15	7500
	PVC filter with 1/2 inch cyclone (hi-vol air samples)	9.0	0.5 → 3.4	X-ray diffraction	15	7500
HCL	Solid sorbent tube	0.5	5.9 → 7.0	Ion chromatography	2	7903

continued

TABLE 2 (con'td)

Sampling and Analysis Methodology

American Crystal Sugar Company
East Grand Forks, Minnesota
HETA 85-046

Substance	Collection Device	Flowrate (Lpm)	Sampling Duration Range (hrs)	Analysis	Detection Limit (ug/sample)	Reference Method 10,11
Sugar beet pulp dust (respirable)	PVC filter with 10mm cyclone	1.7	4.0 → 8.4	Gravimetric	0.01	0600
Sugar dust	FWSB filter	1.5	7.8 → 8.4	Gravimetric	0.01	0500
			INTERCAMPAIGN			
Chromium, hexavalent (insoluble)	PVC filter	1.2	6.3 → 8.4	Visible spectroscopy	0.2	7600
Metals	FWSB filter	1.2	6.3 → 8.4	ICP-AES	See Appendix	7300
Welding fume	PVC filter	1.0	6.3 → 8.4	Gravimetric	0.01	0500

TABLE 3

Environmental Criteria and Health Effects Summary

American Crystal Sugar Company
East Grand Forks, Minnesota
HETA 85-046

Substance	Environmental Criteria[1] (mg/M^3) NIOSH REL	OSHA PEL	ACGIH TLV	Primary Health Effects	References
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.	2,3,4,5
Calcium carbonate (total)	-	15 ppm	10 ppm	Regulated as a nuisance particulate when crystalline silica content in bulk sample is less than one percent. Excessive concentrations of nuisance particulates may cause unpleasant deposits in eyes, ears, and nasal passages, and may seriously reduce wookroom 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 septum.	3,4,5
Carbon monoxide (CO)	35 ppm	50 ppm	50 ppm	Combines with hemoglobin to form carboxyhemoglobin (COHb) which interferes with the oxygen carrying capacity of blood, resulting in tissue hypoxia. Formation of COHb is reversible. Symptoms include headache, drowsiness, nausea, and at high concentrations death can result.	2,3,4,5
Chromium, hexavalent	0.001	0.5	0.05	Lung cancer, skin ulcers and lung irritation.	2,3,4
Coal dust (less 5% quartz)	-	2.4	2.0	Coal worker's pneumoconiosis.	2,3,5
Coal dust (greater than 5% quartz)	-	Crystalline silica formula			
Crystalline silica (respirable)	0.05	$\frac{10\ mg/M^3}{\%\ SiO_2+2}$	$\frac{10\ mg/M^3}{\%\ SiO_2+2}$	Silicosis; a pneumoniosis 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.	2,3,13
Fly ash (respirable)[2]	-	5.0	5.0	Regulated as a nuisance particulate. Refer to health effects for calcium carbonate.	2,3

continued

TABLE 3 (con'td)

Environmental Criteria and Health Effects Summary

American Crystal Sugar Company
East Grand Forks, Minnesota
HETA 85-046

Substance	Environmental Criteria[1] (mg/M^3) NIOSH REL	OSHA PEL	ACGIH TLV	Primary Health Effects	References
Formaldehyde	lowest feasible level	3.7 (3.0 ppm)	1.2(c) (1.0 ppm)	Vapors can cause irritation of the eyes and upper respiratory tract. Animal carcinogen. Contact with liquid can cause both primary irritation and sensitization dermatitis.	2,3,14
Hydrochloric acid (HCl)	7.0	7.0	7.0(c)	A strong irritant of the eyes, muscous membranes, and skin.	2,3,15
Iron oxide (as Fe)	-	5.0	5.0	Fume can cause a benign pneumoconiosis called siderosis.	2,3,15
Nickel, inorganic (as Ni) 3	0.015	1.0	1.0	Respiratory irritation from fume, skin effects; lung and nasal cancer.	5,6,7
Sugar beet pulp dust (respirable)	-	5.0	5.0	Regulated as a nuisance particulate. Excessive concentrations of nuisance particulates may cause unpleasant deposits in eyes, ears, and nasal passages, and may seriously reduce wookroom visibility.	5,6,9
Sugar dust (total)	-	15.0	10.0	Same as above.	5,6,9
Welding fumes (N.O.C)	-	5.0	5.0	Toxicity of component metal must be considered individually. For this particular evaluation refer to hexavalent chromium and inorganic nickel.	5,6

1. Values are in milligram per cubic meter (mg/M^3) and represent time-weighted average (TWA) exposure limits for up to a 10-hour workday unless otherwise specified. ppm = parts per million
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.

(c) ceiling limit - Exposures should not exceed this level

N.O.C. - not otherwise classified

TABLE 4

Crystalline Silica Content in Settled Dust Samples

American Crystal Sugar Company
East Grand Forks, MN
HETA 85-046

February 1-2, 1985

Substance	Crystalline Silica (% by wt.) Quartz	Cristobalite
Beet pulp dust (3 samples)	9.3 to 11.0	<0.75
Limestone	<0.75	<0.75
Coke	<0.75	<0.75
Coal	2.6	<0.75
Fly ash	7.2	<0.75
Laboratory limit of detection (% by wt.):	0.75	0.75

TABLE 5

High Volume Air Samples for Respirable Crystalline Silica

American Crystal Sugar Company
East Grand Forks, Minnesota
HETA 85-046

February 1-2, 1985

Date	Location	Sample Duration	Sample Volume (M^3)	Airborne Concentration (mg/m^3) Respirable Particulate	Quartz	% Quartz
2-1-85	Pellet mill	1007-1618	3.23	2.5	0.068	2.7*
2-2-85	Pulp dryer, B side	1020-1220	1.07	1.4	0.047	3.3*
2-2-85	Lime kiln	1230-1428	1.05	1.4	ND	- *

* Cristobalite was not detected; less than 0.15 mg per sample.

TABLE 6

Calcium Oxide and Calcium Carbonate Exposures of Workers
Associated with the Lime Kiln

American Crystal Sugar Company
East Grand Forks, Minnesota
HETA 85-046

February 1-2, 1985

				Airborne Concentration (mg/m^3)	
Date	Sample Description	Sample Duration	Sample Volume (L)	Calcium Oxide (o) or Calcium Carbonate (c)*	Respirable Particulate
2-1-85	Slaker operator	0737-1558	852	-	1.6
2-2-84	Slaker operator	0738-1544	729	5.2 (o)	-
2-1-85	Limestone/coke mill person	0739-1550	835	-	2.9
2-2-85	Limestone/coke mill person	0748-1558	735	11 (c)	-
2-1-85	Lime kiln foreman	0750-1545	807	-	1.3
2-2-85	Lime kiln foreman	0741-1545	729	9.3 (o)	-
Environmental criteria:		NIOSH REL		- (o) - (c)	-
		ACGIH TLV		2.0 (o) 10 (c)	5.0
		OSHA PEL		5.0 (o) 15 (c)	5.0

* Exposures to calcium carbonate (c) or calcium oxide (o) were assigned to workers based on location; i.e., workers in the vicinity of the lime kiln-calcium oxide, those elsewhere calcium carbonate.

Table 7

Personal and General Area Carbon Monoxide Concentrations

American Crystal Sugar Company
East Grand Forks, Minnesota
February 1-2, 1985

HETA 85-046

Date	Sample Description	Sample Duration	CO Concentration (ppm)
2-1-85	Lime kiln foreman	0750-1545	10
2-2-85	Lime kiln foreman	0741-1545	3
2-1-85	Slaker operator	0737-1558	12
2-2-85	Slaker operator	0738-1544	8
2-1-85	Coke/limerock handler	0945-1550	13
2-2-85	Coke/limerock handler	0748-1558	8
2-2-85	Area sample, gas blower	0815-1537	35
2-2-85	Area sample, gas washer	0810-1537	10
Environmental criteria:	OSHA PEL		50
	NIOSH REL		35

TABLE 8

Respirable Coal Dust and Fly Ash Exposures of Boiler
and Pulp Dryer Coal and Fly Ash Handlers

American Crystal Sugar Company
East Grand Forks, Minnesota
HETA 85-046

February 1-2, 1985

Date	Sample Description	Sampling Duration	Sample Volume (L)	Airborne Concentration (mg/m^3) Coal Dust	Fly Ash	Quartz
2-1-85	Boiler coal handler	0737-1535	956	0.3	-	NA
2-2-85	Boiler coal handler	0737-1607	1028	0.5	-	ND
2-1-85	Boiler ash handler	0915-1537	649	-	0.3	ND
2-2-85	Boiler ash handler	0732-1600	864	-	0.6	ND
2-1-85	Pulp dryer coal handler	0734-1559	1010	0.6	-	ND
2-2-85	Pulp dryer coal handler	0812-1210	476	0.6	-	NA
2-1-85	Pulp dryer ash handler	0742-1602	850	-	2.4	ND
2-2-85	Pulp dryer ash handler	0747-1607	850	-	0.9	ND
Environmental criteria:		NIOSH REL		-	-	0.050
		ACGIH TLV		2.0	5.0	0.100
		OSHA PEL		2.4	5.0	-

ND - Not detected; less than 0.015 mg per sample.
NA - Not analyzed; quartz in these samples would have been nondetectable since the other samples of higher particulate loading were nondetectable.

TABLE 9

Personal Air Samples for Respirable Pulp Dust and Crystalline Silica

American Crystal Sugar Company
East Grand Forks, Minnesota
HETA 85-046

February 1-2, 1985

Date	Sample Description	Sample Duration	Sample Volume (L)	Airborne Concentration (mg/m^3)	
				Pulp Dust	Quartz
2-1-85	Pellet mill operator	0802-1200	405	0.5	NA
2-2-85	Pellet mill operator	0746-1607	852	0.7	ND
2-1-85	Pellet mill mechanic	0749-1547	813	0.4	ND
2-1-85	Pellet mill loader	0735-1558	855	0.3	NA
2-1-85	Pellet mill loader	0735-1558	824	0.7	ND
2-2-85	Pellet mill loader	0731-1553	853	0.6	ND
2-2-85	Pellet mill loader	0731-1553	853	0.4	NA
Environmental criteria:		NIOSH REL		-	0.050
		ACGIH TLV		5.0	0.100
		OSHA PEL		5.0	-

ND = not detected, less than 0.015 mg/sample.
NA = not analyzed; quartz in these samples would have been nondetectable since the other samples of higher particulate loading were nondetectable.

TABLE 10

Personal Sugar Dust Exposures

American Crystal Sugar Company
East Grand Forks, Minnesota
HETA 85-046

February 1-2, 1985

Date	Sample Description	Sample Duration	Sample Volume (L)	Sugar Dust Airborne Concentration mg/m^3
2-1-85	Sugar bin cleaner	0744-1533	703	3.3
2-1-85	Sugar bagger	0741-1540	718	2.9
2-1-85	Sugar bagger	0741-1540	718	7.3
2-2-85	Sugar bagger	0735-1550	742	2.9
2-2-85	Sugar bagger	0736-1550	741	3.4
2-1-85	Sugar bin operator	0736-1524	702	5.6
2-2-85	Sugar bin operator	0743-1541	717	13
2-1-85	Sugar bulk loader	0737-1535	717	1.7
2-2-85	Sugar bulk loader	0736-1601	757	1.4
Environmenatal criteria:	ACGIH TLV			10.0
	OSHA PEL			15.0

Note: Sugar bin operators and cleaner wore approved dust respirators. Reported values for these workers should be considered potential exposures.

TABLE 11

Respirable Amorphous Silica Exposures of Filter Operators

American Crystal Sugar Company
East Grand Forks, Minnesota
HETA 85-046

February 1-2, 1985

Date	Sample Description	Sample Duration	Sample Volume (L)	Airborne Concentration (mg/m^3) Amorphous Silica*
2-1-85	Industrial filter operator A side, charging Harborlite®	0747-1537	799	0.4
2-2-85	Industrial filter operator Aside, charging Harborlite®	0744-1545	818	0.2
2-1-85	Carbonation filter operator B side, charging Dicalite®	1040-1542	513	0.1
2-2-85	Carbonation filter operator B Side, Charging Dicalite®	0801-1610	831	0.6
Evaluation criteria:		NIOSH REL		-
		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) reported values should be considered a maximum.

TABLE 12

General Area Air Samples for Formaldehyde,
Hydrochloric Acid, and Bischloromethylether

American Crystal Sugar Company
East Grand Forks, Minnesota
HETA 85-046

February 1, 1985

Location	Sample Duration		Airborne Concentration (mg/m^3) Formaldehyde*	HCL	BCME**
Screen house I-beam above screen	0855-1525		ND	ND	ND
6-Diffuser at pulp discharge conveyor	0829-1530		ND	ND	ND
Drum filter #2 east side	0935-1530		ND	ND	ND
Environmental criteria:		NIOSH REL	Lowest level feasible	7	Lowest level feasible
		OSHA PEL	3.7	7	Regulated carcinogen
		ACGIH TLV	1.5	7(c)	0.005

* NIOSH and ACGIH consider formaldehyde a potential human carcinogen.
** NIOSH, OSHA, ACGIH regard BCME a confirmed human carcinogen.
C = ceiling limit
ND - not detected; less than 2ug/sample for formaldehyde, 4ug/sample for HCl, and 0.02 ug/ml for BCME

TABLE 13

Personal Air Sampling Results for Welding Fumes

American Crystal Sugar Company
East Grand Forks, Minnesota
HETA 85-046

May 22-23, 1985

Date	Location	Job	Sampling Duration	Sample Volume	Environmental Concentration (mg/M^3)			
					Total Welding Fumes	Hexavalent Chromium	Iron Oxide	Nickel
5-22-85	Diffuser tower area	Misc. welding	0801-1615	494	1.4	0.005		
				692			0.5	0.002
5-23-85	"	"	0756-1525	449	2.0	0.002		
				629			0.1	ND
5-22-85	Insider diffuser	Repairing flights	1004-1622	378	1.8	0.005		
			0803-1622	699			0.9	0.012
5-23-85	"	"	0801-1622	501	2.7	0.013		
				701			1.3	0.011
5-22-85	"	"	0810-1619	489	2.0	0.004		
				685			0.6	0.008
5-23-85	"	"	0802-1329	327	4.1	0.012		
				458			0.7	0.005
5-22-85	"	"	0813-1618	485	2.3	0.004		
				679			0.4	0.006
5-23-85	"	"	0754-1620	506	1.2	0.004		
				708			0.6	0.006
5-22-85	"	"	0807-1617	490	2.0	ND		
				686			0.8	0.003
5-22-85	Pulp presses	Rebuilding spindles	0757-1605*	438	1.4	ND		
				613			0.8	0.003
5-23-85	"	"	0759-1633	514	1.2	ND		
				720			0.6	0.002
5-22-85	Pulp dryer area	Rebuilding pipes	0859-1622	503	5.5	NA		
				704			1.4	ND
5-22-85	Carbonation tank area	Repairing pipes	0817-1621	484	2.6	NA		
				678			2.1	0.003
5-23-85	"	"	0803-1621	498	2.5	NA		
				697			1.3	ND

(continued)

TABLE 13 (con'td)

Personal Air Sampling Results for Welding Fumes

American Crystal Sugar Company
East Grand Forks, Minnesota
HETA 85-046

May 22-23, 1985

Date	Location	Job	Sampling Duration	Sample Volume	Environmental Concentration (mg/M^3)			
					Total Welding Fumes	Hexavalent Chromium	Iron Oxide	Nickel
5-22-85	Sugar bulk loading shed	Lengthening feeder chutes	0818-1623	485	2.8	ND		
				679			0.2	ND
5-23-85	"	"	0825-1628	483	2.3	ND		
				676			0.2	ND
5-22-85	Machine shop	Misc. welding	0821-1615	474	0.6	ND		
	"			663			1.4	0.068
5-23-85	"	"	0805-1615	490	2.2	0.004		
				686			0.2	0.017
5-22-85	"	"	0823-1615	472	3.2	ND		
				661			1.8	0.113
5-23-85	"	"	0806-1616	490	2.3	0.0006		
				686			1.4	0.035
5-22-85	"	Rototec® operator	1247-1335	48	2.1	ND		
				67			0.2	0.58
5-22-85		Lathe operator near Rototec® operation	1249-1335	48	3.5	ND		
				64			0.4	0.42
Environmental criteria:				NIOSH REL		0.001	-	0.015
				OSHA PEL		0.5	5.0	1.0
				ACGIH TLV		0.05	5.0	1.0

* Sampling pump operation interurupted during reported time period. Pump on-time was used to calculate sample volume.

ND = not detected; less than 0.0002 mg/sample for hexavalent chromium or 0.001 mg/sample for nickel.
NA = not analyzed because welding was not done on stainless steel, a primary source of hexavalent chromium.

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

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

APPENDIX

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

American Crystal Sugar Company
East Grand Forks, Minnesota
HETA 85-046

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

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