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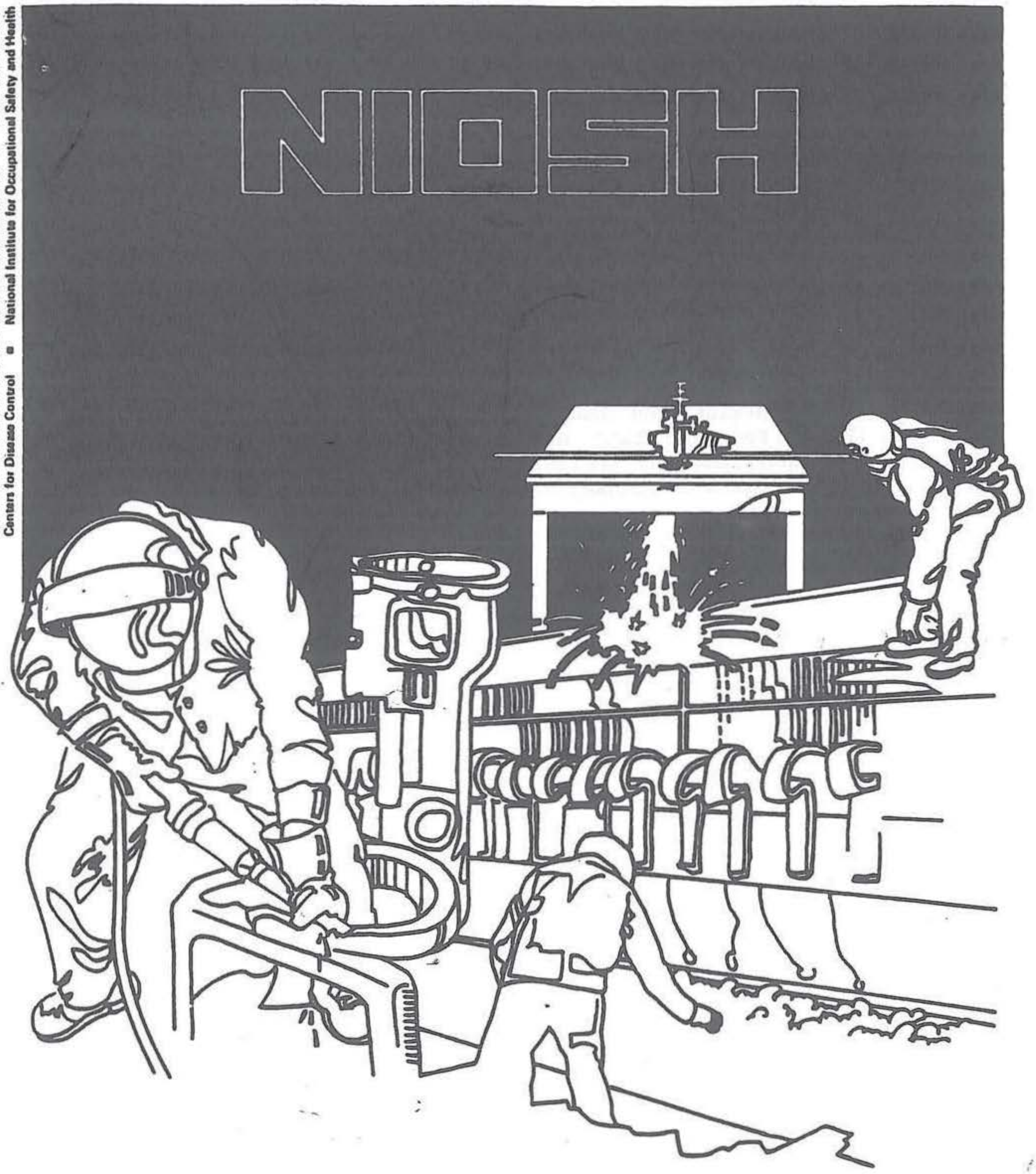

Health Hazard Evaluation Report

HETA 85-043-1760
AMERICAN CRYSTAL SUGAR COMPANY
HILLSBORO, NORTH DAKOTA

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 85-043-1760
DECEMBER 1986
AMERICAN CRYSTAL SUGAR COMPANY
HILLSBORO, NORTH DAKOTA

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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 Hillsboro, North Dakota. In addition, NIOSH was asked to evaluate employee exposures to welding fumes during ACSCo's summer maintenance operations.

On January 28 and 29, 1985, and on June 4 and 5, 1985, NIOSH industrial hygienists conducted environmental surveys at the plant during beet processing activities and summer maintenance activities, respectively.

During the January survey, full-shift personal breathing-zone air samples were collected to characterize employee exposures to amorphous and crystalline silica, bischloromethylether (BCME), calcium carbonate, calcium oxide, carbon monoxide (CO), gypsum, 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, gypsum, and coal dusts 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, formaldehyde and CO.

Analysis of the air samples produced the following ranges of concentrations which are compared with their most stringent environmental criteria (EC): amorphous silica, nondetectable (ND) to 0.8 mg/M^3 (EC = 5.0 mg/M^3); calcium carbonate, 0.9 to 42 mg/M^3 (EC = 10.0 mg/M^3); calcium oxide, 1.5 mg/M^3 (one sample) (EC = 2.0 mg/M^3); carbon monoxide, 4 to 44 ppm (EC = 35 ppm); gypsum, 0.3 to 0.7 mg/M^3 (EC = 5.0 mg/M^3); hydrochloric acid, ND to 0.06 mg/M^3 (EC = 7.0 mg/M^3); pulp dust, 0.2 to 1.3 mg/M^3 (EC = 5.0 mg/M^3); and sugar dust, 3.8 to 84 mg/M^3 (EC = 10 mg/M^3). Air samples for BCME, 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 settled dust and high volume air samples suggests that sugar beet pulp dust is not biologically inert, but rather that it can potentially produce silicosis in exposed workers. Calcium carbonate and sugar dust were the only substances exceeding their respective OSHA standards.

During the June 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, 2.2 to 19 mg/M^3 (EC = 5.0 mg/M^3); iron oxide, 1.0 to 17 mg/M^3 (EC = 5.0 mg/M^3); nickel, 0.002 to 0.432 mg/M^3 (EC = 0.015 mg/M^3); calcium oxide fume, ND to 2.2 mg/M^3 (EC = 2.0 mg/M^3); and insoluble hexavalent chromium, 0.032 (one sample) (EC = 0.001 mg/m^3). The presence of excessive levels of interfering metals prevented quantitation of Cr VI in 10 of 11 personal air samples obtained from workers welding on stainless steel. Despite this limitation we feel that the presence of Cr VI in these samples was probably very likely, especially considering that it was detected in most of the air samples we collected from workers welding on stainless steel at the other ACSCo beet sugar plants, where interferent metal levels were less of a problem. Other compounds or elements detected but at levels below their respective most stringent EC included aluminum oxide, copper, total chromium, manganese, and magnesium oxide. No other elements were detected. Concentrations of total welding fumes and iron oxide exceeded their respective OSHA standards.

On the basis of the data obtained during this investigation, it has been determined that workers at ACSCo's Hillsboro plant were overexposed to calcium carbonate, carbon monoxide, and sugar dust during sugar production operations, and to total welding fumes, hexavalent chromium, iron oxide, nickel, and calcium oxide fume during summer 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, carbon monoxide, sugar dust, welding fumes, hexavalent chromium, nickel, iron oxide, calcium 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 exposure 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 Hillsboro North Dakota. The other four processing plants are located in Drayton, North Dakota (HETA 85-044) and in Crookston (HETA 85-045), East Grand Forks (HETA 85-046), and Moorhead (HETA 85-018), Minnesota. Separate final reports have been prepared for each of these plants.

On December 10 and 11, 1984, NIOSH industrial hygienists conducted a walk-through tour at two of the five plants (East Grand Forks and Crookston). 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 28 and 29, 1985, we evaluated employee exposures to a variety of air contaminants during campaign (sugar processing) activities at the Hillsboro facility. Environmental findings and recommendations from this survey were provided to the company and union, in two interim letter reports, issued in March and August 1985.

On June 4 and 5, 1985, we returned to the facility during summer 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 Description and Workforce

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

The Hillsboro facility, built in 1974, was operated for approximately one year by another firm before ACSCo purchased the plant in 1975. It is the only ACSCo plant utilizing oil-fired equipment. The plant employs 230 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 (intercampaign period), approximately 150 of the 230 production workers are retained on a one-shift, 6-day schedule to repair/maintain various equipment throughout the facility.

During the campaign the Hillsboro plant processes nearly 4100 tons of sugar beets a day, which are grown on approximately 43,000 acres of land in 6 surrounding counties. On the average, approximately 580 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, approaches 225 and 200 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 long noodle-like pieces call "cossettes". The cossettes are conveyed into the bottom of a large inclined cylindrical vessel called the diffuser. Hot water, flowing accross 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 rotary drying drum, and made into pellets for use as livestock feed.

After leaving the inclined diffuser, the raw juice is mixed with milk of lime and carbon dioxide (CO_2) (produced in the lime kilm from the oxidation of $CaCO_3$ using coke as a fuel source) in carbonation vessels in order 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 oil-fired boilers (conversion to coal was imminent; construction of an on site coal-fire power plant was observed during the followup survey). 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 used included conventional shielded metal arc welding and metal inert gas (MIG) welding, on stainless steel and/or carbon (mild) steel. Plasma and oxyacetylene cutting were also performed and evaluated during the survey.

IV. Evaluation Design and Methods

A. Campaign

On January 28 and 29, 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, carbon monoxide (CO), respirable particulates, pulp dust, gypsum, formaldehyde, hydrochloric acid (HCL), and bischloromethylether (BCME). Since most of the particulate materials under investigation potentially contained cystalline silica, we collected bulk dust samples, settled rafter dust samples, and/or respirable high volume (hi-vol) air samples for qualitative and quantitative crystalline silica analyses. Bulk dust or settled rafter dust samples collected for silica analysis included limestone, beet pulp, gypsum, and coke. The respirable hi-vol air samples were collected from two sites in the pellet mill area and from the lime kiln area. 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 dust samples and the high volume air samples were analyzed prior to analysis of the personal air samples. Results of these analyses were used to determine which, if any, of the personal samples for 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 used in assessing exposures to each of these substances is provided below.

Lime kiln workers (i.e., slaker operator, limestone/coke mill person, front end loader) were monitored for exposure to calcium oxide, calcium carbonate, CO, respirable particulates, and cystalline silica.

Long-term personal and general area and short-term general area air samples were collected for CO. Five personal samples were collected over the 2 day period, from a worker in the lime kiln area (slaker operator) as well as workers in the area of the pulp dryer. Stationary air samples were positioned at or near the CO_2 gas blowers or gas washers, where leaks had been occurring.

Four total dust samples were collected from the lime kiln workers, two from the limerock mill person, and one each from the other two workers for elemental calcium analysis. 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, who worked in the vicinity of the lime kiln, was assigned exposure to calcium oxide. The other two workers were assigned exposure to calcium carbonate. Five respirable dust samples were also collected from these workers for gravimetric and crystalline silica analysis, if indicated from results of the bulk sample and/or high volume air sample analyses.

Respirable dust samples were collected from workers potentially exposed to pulp dust. They included the pellet mill operator, pulp dryer foreman, and the bobcat operator. Six air samples were collected, one from each worker each day, and analyzed gravimetrically for pulp dust. Further analysis for crystalline silica depended on whether it was present in the settled rafter dust samples or the high volume samples.

Five total dust samples including four from the sugar bin cleaners and one from the bulk loader were collected and analyzed gravimetrically for sugar dust.

Operators of the juice filtration units were evaluated for exposure to respirable amorphous silica and gypsum. Four air samples were collected from filter operators who handled Harborlite® filter aid, the major component of which is amorphous silica. Two air samples were collected from the carbonation filter operator who handled gypsum.

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 five areas in the plant, near process equipment where HCL and formaldehyde were likely to be present. These included the carbonation station, drum filters, beet slicer bin, pulp presses, and diffuser. We observed that during the time these samples were collected, formaldehyde was added to the diffuser and muriatic acid was used to clean drum filters, a situation that could potentially lead to the formation of BCME.

B. Intercampaign (welding)

On June 4 and 5, 1985, twenty-five workers were monitored via breathing-zone air samples for exposure to welding fumes and specific metals. These workers were exposed to fumes while welding and/or cutting on various process equipment and other structures throughout the plant. Types of welding observed during this survey included arc welding and metal inert gas (MIG) welding. Cutting operations were mostly done using an oxyacetylene torch although one worker used a plasma torch. Base metals included stainless steel and mild steel. 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 in 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 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 and variable, inductively coupled plasma-atomic emission spectroscopy (ICP-AES), a technique which provides for 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 for 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 environemental 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 used; the NIOSH-REL's, by contrast, are based primarily solely on concerns relating to the prevention of occupational disease. In evaluating the exposure levels and the recommedations 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 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 is presented 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 carbonate and sugar dust [5,6]

Available toxicity data indicate that calcium carbonate and sugar dusts would be characterized as "nuisance" particulates. 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.

2. Carbon monoxide [6,7]

Carbon monoxide (CO) is a common and lethal gas produced by incomplete combustion. The prinicpal toxic effect of CO is tissue hypoxia. Inhaled CO causes hypoxia by binding tightly with circulating hemoglobin to produce carboxyhemoglobin (COHb), thus reducing the capacity of the blood to transport oxygen. The brain and heart are the tissues most severely affected by CO-induced hypoxia. Exposures to concentrations of 500 to 1000 causes development of headache, rapid heartbeat, nausea, weakness, and mental confusion. Death can occur when blood contains 60% to 80% CoHb.

3. Total welding fumes, not otherwise classifield[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 $5mg/M^3$ criteria.

In this particular evaluation, nickel, chromium VI, iron oxide, and calcium oxide were the specific metals or metal containing compounds found to be present at concentrations in excess of their exposure criteria in many of the air samples obtained from welders.

4. Chromium [6,8]

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 increased 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. 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.

6. Nickel [5,9]

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 dipigmented 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 workers 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 possiblility 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.

7. Calcium oxide fume[5,6]

Calcium oxide irritates the eyes and upper respiratory tract. The irritant effects are probaly 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; severe irritation of the upper respiratory tract ordinarily causes persons to avoid serious inhalation exposure. Particles of calcium oxide have casued severe burns of the eyes; prolonged or repeated contact with skin could cause dermatitis.

VI. Results

A. Campaign

1. Bulk dust samples, settled rafter dust samples, and high volume air samples for crystalline silica.

Table 4 presents the results of the crystalline silica analysis on the bulk dust and settled rafter dust samples. Measurable quantities of quartz were detected in all three beet pulp dust samples, with concentrations ranging from 3.6 to 4.3%, by weight. Cristobalite was not detected in concentrations greater than the limit of detection for the analysis (0.75%, by weight). Quartz and cristobalite were not detected in samples of limestone, coke, or gypsum (less than 0.75%, by weight).

Results of the hi-vol air samples for crystalline silica are presented in Table 5. Both air samples obtained from the pellet mill area contained detectable quantities of silica (quartz). The silica content of these respirable dust samples was measured at 7.1 and 5.2%. No cristobalite was detected in these samples (less than 0.015 mg per sample). 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 6-11, along with applicable environmental criteria.

Air sampling results for calcium oxide, calcium carbonate, and respirable particulates for those employees associated with the lime kiln are presented in Table 6. One sample collected from the slaker operator revealed an airborne exposure to calcium oxide of 1.5 mg/M^3. This level, by comparison, was below the ACGIH TLV and OSHA PEL of 2.0 and 5.0 mg/M^3, respectively.

Crystalline silica analysis was not performed on the five respirable dust samples obtained from the lime kiln workers since it was not detected in limestone and coke settled rafter dust samples or hi-vol samples. The measured air concentrations, ranging from 0.01 to 1.8 mg/M^3, are therefore compared to the nuisance dust standard of 5.0 mg/M^3.

Long-term and short-term measurements for CO are presented in Tables 7a and 7b, respectively. The CO measurements were taken while the company was experiencing problems with the lime kiln gas washer, which consequently resulted in the release of rather high levels of CO into the gas washer room and adjacent areas. Worker exposure was limited to some extent since the company restricted access to this area. One worker (slaker operator), who spent more time than any worker in this area on January 28th, was exposed to 44 parts per million (ppm) (8-hour TWA) which exceeds the NIOSH REL of 35 ppm. Limited work activity in this area the following day accounted for a much lower exposure (4 ppm) for this individual. CO exposures of two other workers working in the area of the pulp dryer (an area adjacent to the lime kiln) did not exceed 11 ppm.

Two short-term samples taken inside the gas washer room on January 29, either met or exceeded the NIOSH ceiling limit of 200 ppm. Company CO monitoring data indicated that CO levels just outside the gas washer room (where their stationary monitor was located) varied considerably throughout the 2-day period, with the highest level reaching 2000 ppm. This level was above the 1500 ppm level considered to be immediately dangerous to life and health.

Results of the personal air samples collected for respirable pulp dust are presented in Table 8. Because crystalline silica was found in both the settled rafter dust and the respirable hi-vol dust samples, the personal samples were submitted for silica analysis. Of the six samples, those with the highest particulate load from each job were analyzed first. None of these three 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 0.2 to 1.3 mg/M^3.

Sugar dust sampling results are presented in Table 9. Four total dust samples collected from the bin cleaners during routine housekeeping activities ranged from 46 to 84 mg/m^3, all exceeding the ACGIH TLV of 10 mg/M^3 and OSHA PEL of 15 mg/M^3, respectively. During bulk loading of sugar into rail cars the bulk loader was exposed to 3.8 mg/M^3.

Air sampling results for amorphous silica and gypsum are presented in Table 10. Amorphous silica exposures of filter operators dumping bags of Harborlite® filter aid ranged from nondetectable (less that 0.01 mg per sample) to 0.8 mg/M^3, compared to the ACGIH TLV of 5.0 mg/M^3. Since the analysis was not specific for amorphous silica, the reported values should be considered a maximum as other (less toxic) materials are present in Harborlite®. Filter operators dumping bags of gypsum had exposures of 0.3 and 0.7 mg/M^3. Since no crystalline silica was found in a bulk sample of this material, the exposures are comparable to the respirable nuisance dust standard of 5.0 mg/M^3.

Results of the general area air sampling for formaldehyde, HCL, and BCME are presented in Table 11. Of these three substances, HCL was the only one detected. Concentrations ranged up to 0.06 mg/M^3, and were well below the NIOSH REL and OSHA REL of 7.0 mg/M^3.

B. Intercampaign (Welding)

Air sampling results are presented in Table 12. Airborne concentrations are provided for total welding fumes and for those elements or compounds which were present at concentrations greater than 50% of their respective most stringent occupational exposure limits. Other elements which were detected but no higher than this "action level" are identified in Table 12, along with those elements which were nondetectable.

Airborne concentrations of total welding fumes ranged from 2.2 to 19 mg/m^3. Sixteen (67%) of the personal breathing-zone (BZ) samples exceeded the OSHA PEL of 5.0 mg/M^3. Specific elements or compounds which were detected at concentrations greater than their action level include total chromium, hexavalent chromium, iron oxide, nickel, calcium oxide, and manganese. Total chromium levels ranged from nondetectable (ND) to 0.3 mg/M^3. None of these samples exceeded the ACGIH TLV of 0.5 mg/M^3. Ten of 11 air samples analyzed for insoluble hexavalent chromium (Cr VI) could not be quantitated because interferences (excessive levels of copper, iron, and nickel) were present in the samples. In the one sample where Cr VI was quantified, it was present at a concentration of 0.032 mg/M^3 which, by comparison, exceeded the NIOSH REL of 0.001 mg/M^3. Iron oxide concentrations ranged from 1.0 to 17 mg/M^3. Eight (33%) of the samples for nickel either met or exceeded the NIOSH REL of 0.015 mg/M^3, while none exceeded the OSHA PEL of 1.0 mg/M^3.

Calcium oxide fume concentrations ranged from ND to 2.2 mg/M^3. One (4%) of the samples exceeded the ACGIH TLV of 2.0 mg/M^3. Airborne concentrations of manganese fume (as Mn) ranged from 0.02 to 0.8 mg/M^3. None of these samples exceeded the ACGIH TLV of 1.0 mg/M^3. Elements which were detected but at levels below half of their most stringent environmental criteria include aluminum, copper, and magnesium. All other elements included in the analysis were nondetectable.

VII. Discussion and Conclusions

A. Campaign

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

Excessive CO levels in the lime kiln process was attributed to leaks in the CO_2 gas washer equipment. The company was aware of the problem and had taken necessary precautions to minimize CO exposure to workers in this area until the equipment could be replaced. Temporary repairs were made to the gas washer equipment shortly after our site visit. During the intercampaign period, the entire CO_2 gas washer system was replaced.

Calcium carbonate (limestone) overexposures of selected lime kiln personnel appeared to be due in part to the open conveyor system used to transfer the rock from the storage area to the kiln. Accumulation of loose material below the conveyor suggests that the system is generating dust and consequently is labor intensive in terms of housekeeping needs.

Based on our observations of the sugar bin cleaners, we believe that the excessive levels of sugar dust measured in their personal air samples primarily resulted from use of dry sweeping methods to remove sugar dust which had accumulated along the conveyor system and on other equipment in the sugar storage silos. Although a central vacuum system was present along the conveyor bins and in other areas, it did not appear to be used as much as it should have been.

Crystalline silica analysis of pulp dust bulk samples and high volume air samples taken in the vicinity of pulp handling equipment shows that the pulp dust contains appreciable amounts of (3-7%) crystalline silica. Based on this information, we believe, that the pulp dust should be treated as a material that can potentially cause silicosis in exposed workers.

Despite the fact that pulp dust exposures were relatively low, much higher exposures were likely considering the numerous sources of pulp dust emissions we observed from various pulp handling equipment. These sources included leaks in the pulp dryer, pulp dryer cyclones, and along the beet pulp conveyor system. Excessive dust accumulation was noted on most work surfaces and equipment which can contribute to exposures via reentrainment.

BCME formation appears to be remote considering how well formaldehyde and HCl emissions are controlled and also due to the fact that these substances are not used in the immediate vicinity of one another.

B. Intercampaign

The results of the environmental sampling indicated that workers engaged in welding and cutting operations were overexposed to a variety of metals during this survey. As anticipated, workers welding on stainless steel were exposed to much higher concentrations of total chromium, nickel, and manganese than workers welding on carbon steel. Excessive exposures 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.

Despite the fact that interferences presented the quantitation of insoluble Cr Vl in all but one of the air samples analyzed for this compound, there is a good possibility that insoluble Cr VI was present in the remaining 10 air samples, especially considering that it was detected in most of the air samples NIOSH collected from workers welding/cutting on stainless steel at the East Grand Forks facility where interferences were less of a problem.

The degree of exposure to welding fume is dependent on a number of factors including arc time, gauge and composition of base metals, work practices including the use of respirators, and whether contaminant removal systems were used. Probably the two most important factors associated with the excessive metal fume exposures observed during this survey were the lack of local exhaust ventilation and respiratory protection for all welding jobs evaluated, including those conducted in confined spaces (i.e., diffuser tower and beet washer wheel trough) where the highest concentrations of total welding fumes and metals were measured.

The extent of the welding fume exposures (two-thirds of the personal samples exceeded the most stringent occupational exposure criteria for one or more metals and/or total welding fumes) and the fact that the carcinogens nickel and hexavalent chromium were present in most of the air samples underlie the need for good control measures to reduce worker exposures.

VIII. Recommendations

In view of the findings of the environmental evaluation the following recommendations (provided to the company and union via interim reports) were made to ameoliorate 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. The calcium oxide, lime rock, and coke conveyor systems should be either automated and/or enclosed to minimize dust levels present in the kiln area. 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.

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 bulk pulp dust samples and in the high volume samples underlies the need for improvements to be made in the dust collection systems servicing the pulp/pellet conveyor systems as well as the conveyors themselves. Reducing dust emissions from this environment should significantly reduce the housekeeping requirements in the pellet mill and the exposures associated with cleaning activities. Furthermore, the presence of crystalline silica in the pulp dust underlies the need for the use of appropriate respiratory protection, as an interim control measure, until engineering controls are implemented.

3. In order to reduce airborne sugar dust levels in the Weibul bins consideration should be given to fully enclosing the conveyor system. We also recommend that the central vacuum system be used as much as possible to remove sugar dust accumulations, instead of dry sweeping. In areas not serviced by the central vacuum system, portable vacuum systems should be used, where practicable. Until engineering controls are implemented the sugar bin workers should continue to use appropriate dust respirators in areas where visible airborne dust is present.

4. Exposure of the sugar bulk loader, although below applicable health standards could be further reduced by: (1) providing covers over openings on top of railroad cars when sugar is loaded and (2) repairing the central vacuum system so that spills can be removed by vacuum instead of dry sweeping.

5. The new gas washer and blowers should be periodically checked to verify that CO levels are within acceptable limits.

6. A number of safety hazards were noted throughout the plant during the January site visit. These pertained to poor lighting, slippery floors, and standing water near electrical equipment. Areas where one or more of these conditions existed include the pulp conveyor incline, beet washer house "pit", and in building 26. These conditions should be corrected as soon as possible in order to minimize slip/fall related injuries.

7. Portable local exhaust ventilation (LEV) systems, similar to the type used at the East Grand Forks plant, should be used when welding or cutting in confined spaces. In non-confined work areas, particulary when working with stainless steel, a source of carcinogenic hexavalent chromium, nickel, and other relatively toxic metals LEV systems should be used. When using LEV systems, the hood (typically the end of flexible duct) should be placed as close as practicable to the arc site to ensure maximum capture of fumes. 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 contaminant-free. Reevaluation of welding fume exposures should be done following implementation 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 filters would be effective for carbon steel welding fumes provided that gaseous co-contaminants are not present at 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. Since welding and other fume-producing operations are routinely done in the machine shop, local 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 practicable to the part being welded.

11. 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.

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

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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, Hillsboro Plant
2. American Crystal Sugar Company, Corporate Office
3. American Federation of Grain Millers, Local 264
4. American Federation of Grain Millers, Minneapolis, Minnesota
5. OSHA, Region VIII

Table 1

Potential Exposures During Campaign (Sugar Processing)

American Crystal Sugar Company
Hillsboro, North Dakota
HETA 85-043

January 28-29, 1985

Area	Job Classifications of Monitored Workers	Potential Exposure(s)	Source(s) of Contaminants
Lime kiln, coke, limestone stockpiles	Limestone/coke mill person slaker operator and front end loader operator	Coke, limestone, calcium oxide, and carbon monoxide	Coke, limerock and calcium oxide conveyors; dumping of coke/limerock into bucket elevator. CO is incomplete combustion product from conversion of $CaCO_3$ to CaO in lime kiln.
Carbonation, diffuser, pulp press areas	No personal samples collected	Formaldehyde, hydrochloric acid, and bischloromethyl ether	Formaldehyde piped into inclined diffuser to control bacteria. Formaldehyde is received and stored as liquid. Diffuser not vented due to vertical configuration. Consequently, fugitive formaldehyde vapor emissions are not likely to occur. BCME is not used at plant but may be found from interaction of HCl and formaldehyde.[10]
Pulp pellet mills	Pellet mill operator, bob cat operator, pulp dryer foreman	Sugar beet pulp dust, crystalline silica	Pellet machines, pellet transfer equipment such as conveyors, front end loaders; ventilation equipment; housekeeping activities.
Industrial and carbonation filter areas	Filter operators	Amorphous silica and gypsum	Manual bag charging of Harborlite® filter aid or gypsum into hoppers.
Weibul bins, bulk loading bldg.	Sugar bin cleaners and bulk loader	Sugar dust	Housekeeping activities including dry sweeping, bulk loading of sugar into rail cars.

TABLE 2

Sampling and Analysis Methodology

American Crystal Sugar Company
Hillsboro, North Dakota
HETA 85-043

Substance	Collection Device	Flowrate (Lpm)	Sampling Duration Range (hrs)	Analysis	Detection Limit (ug/sample)	NIOSH Reference Method[11,12]
			CAMPAIGN			
Amorphous silica (respirable)	PVC filter with 10mm cyclone	1.7	7.8 → 8.2	Gravimetric	0.01	0600
Bischloromethyl ether (BCME)	Impinger containing 15 mls 2,4,6-trichloro 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	7.4 → 8.0	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	9.0*	0.5 → 3.4	X-ray diffraction	15	7500
Hydrochloric Acid	Solid sorbent tube	0.5	5.9 → 7.0	Ion chromatography	2	7903
Pulp dust (respirable)	PVC filter with 10mm cyclone	1.7	4.0 → 8.4	Gravimetric	0.01	0600

continued

TABLE 2 (con'td)

Sampling and Analysis Methodology

American Crystal Sugar Company
Hillsboro, North Dakota
HETA 85-043

Substance	Collection Device	Flowrate (Lpm)	Sampling Duration Range (hrs)	Analysis	Detection Limit (ug/sample)	NIOSH Reference Method[11,12]
Sugar dust	FWSB filter	1.5	7.8 → 8.4	Gravimetric	0.01	0500
			INTERCAMPAIGN			
Chromium, hexavalent (insoluble)	PVC filter	1.2	5.2 → 10.4	Visible spectroscopy	0.02	7600
Metals	FWSB filter	1.2	5.2 → 10.4	ICP-AES	See Appendix	7300
Welding fume (total)	PVC filter	1.0	5.2 → 10.4	Gravimetric	0.01	0500

* High volume air samples.

TABLE 3

Evaluation Criteria and Health Effects Summary

American Crystal Sugar Company
Hillsboro, North Dakota
HETA 85-043

Substance	Evaluation Criteria[1] (mg/M^3)			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.	3,4,13
Bischloromethylether(BCME)	lowest level feasible	regulated carcinogen	0.005 (0.001 ppm)	Associated with an increased incidence of lung cancer in humans, highly carcinogenic in rodents.	2,3,4
Calcium oxide dust (total) Calcium oxide fume	-	5.0	2.0	Causes irritation of the eyes, muscous membrance, and skin. Dust inhalation may cause ulceration and perforation of the nasal system.	3,4,5
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.	3,4,5
Carbon monoxide	35 ppm 200 ppm(c)	50 ppm	50 ppm 400 ppm (STEL)	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 included headache, drowsiness, nausea, and at high concentrations death can result.	2,3,4,5
Chromium	-	1.0	0.5	Severe upper respiratory irritant, nasal ulceration.	3,4,5
Chromium, hexavalent (insoluble)	0.001	0.5	0.05	Lung cancer, skin ulcers and lung irritation.	2,3,4,5
Crystalline silica (respirable)	0.05	$\frac{10mg/M^3}{\% SiO_2+2}$	$\frac{10 mg/M^3}{\% SiO_2+2}$	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.	3,4,14
Formaldehyde	lowest level feasible	3.7 (3.0 ppm)	3.0(c)	Vapors can cause irritation of the eyes and upper respiratory tract. Animal carcinogen contact with liquid can cause both primary irritation and sensitization dermatitis.	3,4,15
Gypsum (respirable)[2]	-	5.0	5.0	Regulated as a nuisance particulate. Refer to calcium carbonate for health effects.	3,4

continued

TABLE 3 (con'td)

Evaluation Criteria and Health Effects Summary

American Crystal Sugar Company
Hillsboro, North Dakota
HETA 85-043

Substance	Evaluation Criteria[1] (mg/M^3) NIOSH REL	OSHA PEL	ACGIH TLV	Primary Health Effects	References
Hydrochloric acid (HCl)	7.0	7.0	7.0(c)	A strong irritant of the eyes, muscous membrances, and skin.	3,4,16
Iron oxide (as Fe)	-	5.0	5.0 (10.0 STEL)	Siderosis - a benign pneumoconiosis or respiratory condition associated with inhalation of particulate.	3,4,16
Manganese fume (as Mn)	-	5.0 (c)	1.0 (3.0 STEL)	Manganism - central nervous system effects of chronic intoxication; metal fume fever.	3,4,5
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[2] (respirable)	-	5.0	5.0	Regulated as a nuisance particulate. Refer to calcium carbonate for health effects.	3,4
Sugar dust (total)	-	15.0	10.0	Same as above.	3,4
Welding fumes (N.O.C)	-	5.0	5.0	Toxicity of component metal must be considered individually.	3,4

1. Values are in milligrams 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% (be weight) quartz in bulk dust sample. If greater than 1% personal samples must be analyzed for crystalline silica and compared to its evaluation criteria.

3. OSHA nickel standard is given for the metal and soluble compounds as Ni.

(c) - Ceiling limit. Exposure shall not exceed this concentration.

N.O.C - Not otherwised classified.

STEL - Short Term Exposure Limit.

TABLE 4

Crystalline Silica Content in Settled Dust Samples

American Crystal Sugar Company
Hillsboro, North Dakota
HETA 85-043

January 28-29, 1985

Substance	Crystalline Silica (% by wt.) Quartz	Crystalline Silica (% by wt.) Cristobalite
Beet pulp dust (3 samples)	3.6 to 4.3	<0.75
Limestone	<0.75	<0.75
Gypsum	<0.75	<0.75
Coke	<0.75	<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
Hillsboro, North Dakota
HETA 85-043

January 28-29, 1985

Date	Location	Sample Duration	Sample Volume (M^3)	Airborne Concentration (mg/m^3) Respirable Particulate	Quartz	% Quartz
1-28-85	Pellet mill, near dust scroll	0855-1050	1.00	117	8.3*	7.1
1-28-85	Pellet mill, at base of cyclones	1328-1403	0.30	15.4	0.8*	5.2
1-29-85	Limestone/Coke Conveyor	1146-1510	1.80	0.3	ND*	-

* Cristobalite was not detected; less than 0.015 mg per sample.
ND - not detected; less than 0.015 mg per sample.

TABLE 6

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

American Crystal Sugar Company
Hillsboro, North Dakota
HETA 85-043

January 28-29, 1985

Date	Sample Description	Sample Duration	Sample Volume (L)	Airborne Concentration (mg^2/m^3) Calcium oxide (o) or Calcium carbonate (c)*	Respirable Particulates
1-28-85	Slaker operator	0758-1538	690	1.5(o)	-
1-29-85	Slaker operator	0752-1556	823	-	0.3
1-28-85	Limestone/coke mill person	0804-1556	504	15(c)	-
1-28-85	Limestone/coke mill person	0804-1556	802	-	0.8
1-29-85	Limestone/coke mill person	0725-1557	768	42(c)	-
1-29-85	Limestone/coke mill person	0725-1557	870	-	1.8
1-28-85	Front end loader	0801-1555	771	0.1(c)	-
1-28-85	Front end loader	0801-1555	806	-	0.2
1-29-85	Front end loader	0737-1553	843	-	0.01
Environmental criteria:		NIOSH REL		-(o) -(c)	-
		ACGIH TLV		2.0(o) 10(c)	5.0
		OSHA PEL		5.0(o) 15(c)	5.0

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

Table 7a

Long-Term Carbon Monoxide Measurements

American Crystal Sugar Company
Hillsboro, North Dakota
HETA 85-043

January 28-29, 1985

Date	Sample Description	Sampling Duration	CO Concentration (ppm)
1-28-85	Slaker operator	0795-1538	44
1-28-85	Area sample, at entrance to gas washer room	0926-1600	82
1-28-85	Area sample, at gas blower between separator and skip hoist	1050-1600	13
1-29-85	Slaker operator	0752-1556	4
1-29-85	Area sample, on company CO monitor, outside gas washer room	0718-1534	18
1-29-85	Area sample, inside gas washer room	0720-1534	68
1-29-85	Slaker room	710-1534	5
1-29-85	Pulp dryer foreman	750-1559	11
1-29-85	Front end loader	737-1553	7
NIOSH REL			35
OSHA PEL			50

Table 7b

Short-term Carbon Monoxide Measurements

American Crystal Sugar Company
Hillsboro, North Dakota
HETA 85-043

January 29, 1985

Sample Description	Sample Time	CO Concentration (ppm)
Gas blower area (doors open)	0712	10
Slaker room (doors open)	0715	10
Inside gas washer room	0724	400
Inside lime kiln control room	0727	20
Inside gas washer room	1100	200
NIOSH REL:		200 (ceiling)

TABLE 8

Personal Samples for Respirable Pulp Dust and Crystalline Silica

American Crystal Sugar Company
Hillsboro, North Dakota
HETA 85-043

January 28-29, 1985

Date	Sample Description	Sample Duration	Sample Volume (L)	Airborne Concentration (mg/m^3)	
				Pulp Dust	Quartz
1-28-85	Pellet mill operator	0747-1601	840	1.3	ND
1-29-85	Pellet mill operator	0817-1600	787	0.3	NA
1-28-85	Pulp dryer foreman	0750-1605	841	0.6	ND
1-29-85	Pulp dryer foreman	0750-1559	831	0.2	NA
1-28-85	Bob cat operator, pellet loading	0808-1557	797	0.6	ND
1-29-85	Bob cat operator, pellet loading	0754-1600	826	0.3	NA
Environmental Criteria:		NIOSH		-	0.05
		ACGIH		*	0.10
		OSHA		*	

ND - Not detected; less than 0.015 mg/sample.

NA - Not analyzed; quartz in this sample would have been nondetectable since the other samples of higher particulate loading were nondetectable.

* Although quartz was not detected in these samples it was, however, detected in both the settled rafter samples and the high volume air samples. Based on this data, pulp dust should not be considered an inert dust but rather one that can potentially cause silicosis in exposed workers.

TABLE 9

Personal Sugar Dust Exposures

American Crystal Sugar Company
Hillsboro, North Dakota
HETA 85-043

January 28-29, 1985

Date	Sample Description	Sample Duration	Sample Volume (L)	Sugar Dust Airborne Concentration (mg/m^3)
1-28-85	Sugar bin cleaner	0810-1559	703	69
1-28-85	Sugar bin cleaner	0811-1559	702	84
1-29-85	Sugar bin cleaner	0734-1556	753	46
1-29-85	Sugar bin cleaner	0735-1556	751	46
1-29-85	Sugar bulk loader	0759-1553	805	3.8
Environmental Criteria:		ACGIH OSHA		10 15

Note: All sugar bin cleaners wore approved disposable dust respirators. Reported values therefore represent potential exposures.

TABLE 10

Respirable Amorphous Silica and Gypsum Exposures of Filter Operators

American Crystal Sugar Company
Hillsboro, North Dakota
HETA 85-043

January 28-29, 1985

Date	Sample Description	Sample Duration	Sample Volume (L)	Airborne Concentration (mg/m^3) Amorphous silica* (Harborlite®)	Gypsum
1-28-85	Industrial filter operator	0749-1600	835	0.4	-
1-29-85	Industrial filter operator	0743-1603	867	0.8	-
1-28-85	2nd Carbonation utility man/ filter operator	0800-1553	804	ND	-
1-29-85	2nd Carbonation utility man/ filter operator	0800-1545	791	0.5	-
1-28-85	Carbonation filter operator	0758-1602	823	-	0.3
1-29-85	Carbonation filter operator	0742-1602	857	-	0.7
Evaluation Criteria:		ACGIH:		5.0	5.0
		OSHA:			5.0

* Amorphous silica is the major component in Harborlite® filter aid. Since the analysis was gravimetric (i.e., not specific for amorphous silica) reported values should be considered a maximum.

ND - Not detected; less than 0.015 mg/sample for quartz and cristobalite.

TABLE 11

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

American Crystal Sugar Company
Hillsboro, North Dakota
HETA 85-043

January 29, 1985

Location		Sample Duration	Airborne Concentration (mg/m^3) Formaldehyde*	HCL	BCME**
Carbonation station		0900-1610	ND	ND	ND
Peterson drum filter #1		0905-1610	ND	0.06	ND
Beet bin, above rotary slicers		0910-1610	ND	0.01	ND
Cat walk, above #1 pulp press		0940-1610	ND	0.02	ND
Diffuser, center tower entrance		0929-1610	ND	ND	ND
Environmental Criteria:	NIOSH		Lowest level feasible	7	Lowest level feasible
	OSHA		3.7	7	Regulated carcinogen
	ACGIH		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 that 2 ug/sample for formaldehyde, 4 ug/sample for HCl, and 0.002 ug/ml for BCME.

TABLE 12

Personal Air Sampling Results for Welding Fumes

American Crystal Sugar Company
Hillsboro, North Dakota
HETA 85-043

June 4-5, 1985

Date	Location	Job	Sampling Duration	Sample Volume (Liters)	Environmental Concentration (mg/M^3)						
					Total Welding Fumes	Total Chromium	Hexavalent Chromium	Iron Oxide	Nickel	Calcium Oxide	Manganese
6-4-85	Inside diffuser	Installing flights	0703-1519*	486	8.5		**				
				583		0.1		1.6	0.015	0.2	0.1
6-5-85	"	"	0704-1523*	500	5.8		**				
				600		0.1		4.3	0.027	0.3	0.2
6-4-85	"	"	0708-1521*	413	11		**				
				496		0.1		4.5	0.015	0.5	0.3
6-5-85	"	"	0702-1523*	316	12		**				
				379		0.3		5.7	0.042	0.4	0.4
6-4-85	"	"	0653-1522*	515	4.7		**				
				610		trace		1.9	0.013	0.2	0.1
6-5-85	"	"	0648-1523	515	6.7		**				
				622		0.1		4.0	0.019	0.1	0.2
6-4-85	"	"	0657-1521	504	5.1		**				
				605		0.1		3.3	0.018	0.2	0.1
6-5-85	"	"	0650-1524	516	11		**				
				619		trace		7.4	0.011	0.4	0.3
6-4-85	Wash house	Replacing exterior wall of beet wheel	0659-1514*	492	11		NA				
				590		ND		5.3	0.003	0.3	0.2
6-5-85	"	"	0705-1518*	466	19		NA				
				559		ND		17	0.004	1.0	0.8
6-4-85	"	"	0719-1255	336	3.3		NA				
				403		ND		2.5	0.004	0.1	0.1
6-4-85	Inside pulp dryer	Installing feeder paddles	0650-1528*	454	4.8		NA				
				534		trace		4.7	0.006	0.1	0.2
6-5-85	"	"	0652-1529*	488	2.8		NA				
				586		trace		1.0	0.002	0.2	trace
6-4-85	"	"	0703-1528	505	4.5		NA				
				606		ND		2.9	0.002	0.2	0.1
6-5-85	"	"	0701-1528*	509	5.1		NA				
				611		ND		7.5	0.002	ND	0.3
6-4-85	Centrifugals	Installing exterior supports	0705-1521*	494	8.1		NA				
				593		trace		4.5	0.004	0.2	trace
6-5-85	"	"	0708-1520	492	3.0		NA				
				590		trace		3.0	0.003	0.2	trace

(continued)

TABLE 12 (con'td)

Personal Air Sampling Results for Welding Fumes

American Crystal Sugar Company
Hillsboro, North Dakota
HETA 85-043

June 4-5, 1985

Date	Location	Job	Sampling Duration	Sample Volume (Liters)	Environmental Concentration (mg/M^3)						
					Total Welding Fumes	Total Chromium	Hexavalent Chromium	Iron Oxide	Nickel	Calcium Oxide	Manganese
6-4-85	Vacuum pans	Installing catwalk under pans	0717-1455*	423	2.2		NA				
				508		ND		1.3	0.002	0.1	trace
6-5-85	"	"	0700-1524*	477	3.6		NA				
				572		trace		3.8	0.004	0.1	trace
6-4-85	Old welding shop	Repairing diffuser flights	0652-1506	494	12		0.032				
				593		0.3		6.3	0.19	0.5	0.2
6-5-85	"	"	0810-1529*	402	6.6		**				
				482		trace		6.53	0.010	0.5	0.3
6-5-85	Knife station	Installing new CO_2 pipe line	0707-1525*	456	5.1		NA				
				574		trace		2.8	0.007	0.7	trace
6-5-85	Vacuum pump area	installing pump	0835-1515	400	6.3		NA				
				480		trace		3.6	0.009	2.2	0.1
6-5-85	Diffuser tower area	Plasma torch cutting	0716-1518	482	10		**				
				578		trace		8.4	0.43	0.2	0.2
Environmental criteria:				NIOSH	-	-	0.001	-	0.015	-	-
				OSHA	5.0	1.0	0.5	5.0	1.0	5.0	5.0
				ACGIH	5.0	0.5	0.05	5.0	1.0	2.0	1.0

* Sampling pump operation interrupted during reported time period because of restricted flow condition (pinched hose) or lunch break. In either case, the pumps on-time was used to calculate sample volumes.

** Interferences in sample prevented quantitation of hexavalent chromium.

ND = Not detected; less than 0.001 mg per sample for nickel and copper.
NA = Not analyzed because welding was not done on stainless steel, a source of hexavalent chromium.

Trace = Less than 0.05 mg/M^3 for total chromium and for manganese.

NOTE: Other elements or compounds which were detected in air samples included: aluminum oxide, copper, and magnesium oxide. None of these, however, exceeded 50% of their respective (most stringent) environmental exposure limits.

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

APPENDIX

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

American Crystal Sugar Company
Hillsboro, North Dakota
HETA 85-043

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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