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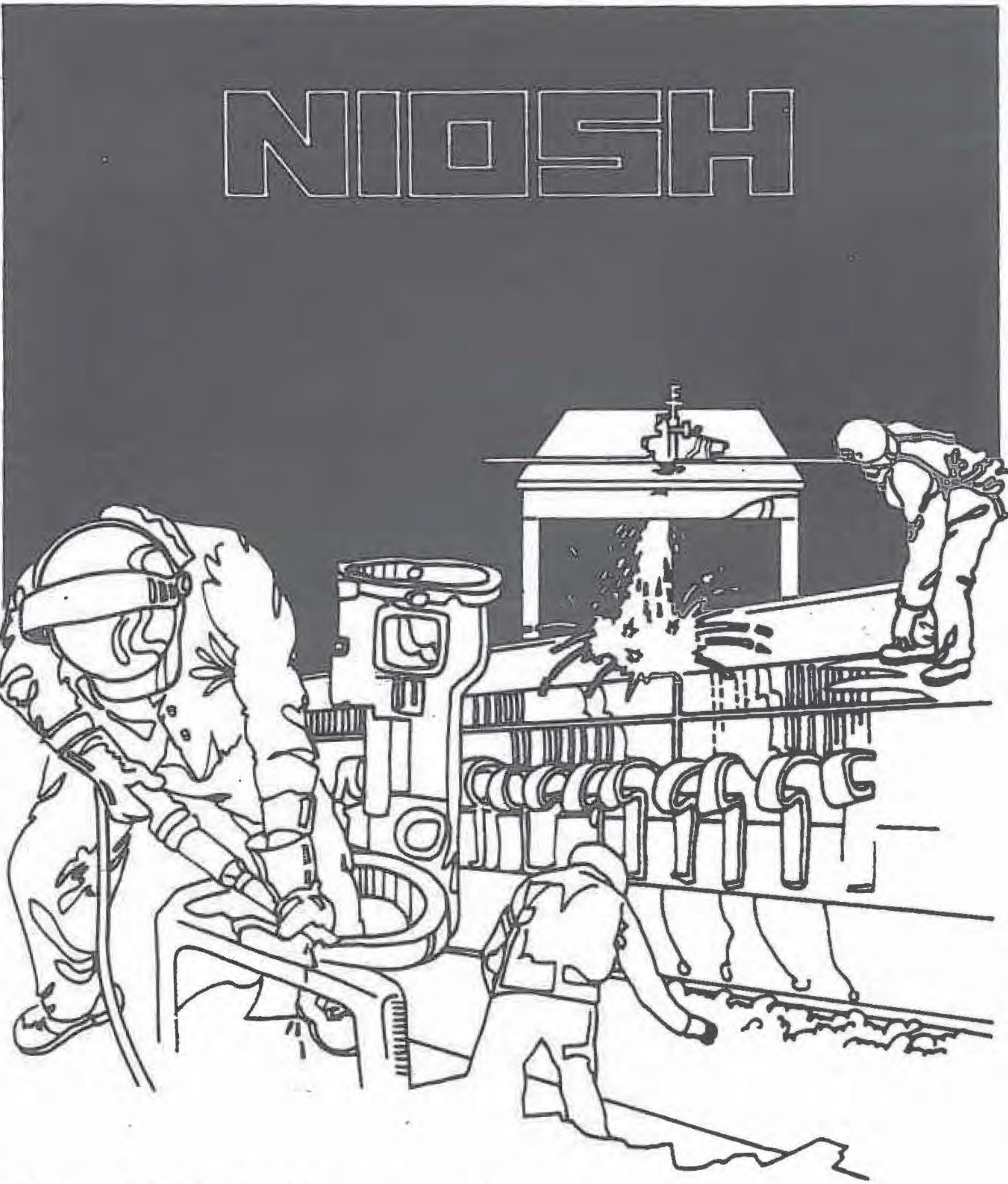

Health Hazard Evaluation Report

HETA 85-045-1762
AMERICAN CRYSTAL SUGAR CO.
CROOKSTON, 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 85-045-1762
DECEMBER 1986
AMERICAN CRYSTAL SUGAR CO.
CROOKSTON, 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 Crookston, Minnesota. In addition, NIOSH was asked to evaluate employee exposures to welding fumes during ACSCo's summer maintenance operations.

On January 15 and 16, 1985, and on June 18 and 19, 1985, NIOSH industrial hygienists conducted environmental surveys at the plant, during beet processing activities and intercampaign maintenance activities, respectively.

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

Analysis of the personal air samples produced the following ranges of concentrations which are compared with their most stringent environmental criteria (EC): amorphous silica, 0.1 to 1.3 mg/M^3 (EC = 5.0 mg/M^3); coal dust, 0.5 to 0.8 mg/M^3 (EC = 2.0 mg/M^3); formaldehyde, nondetectable (ND) to 0.09 mg/M^3 [EC = lowest feasible level (LFL)]; respirable pulp dust, 0.1 to 0.4 mg/M^3 (EC = 5.0 mg/m^3); sugar dust, 0.5 to 13.4 mg/M^3 (EC = 10.0 mg/M^3); and total particulates, 4.9 to 11.2 (EC = 10.0 mg/M^3). General area air samples for formaldehyde ranged from ND to 0.25 mg/M^3 (EC = LFL) and those for HCl ranged from ND to 0.06 mg/M^3 (EC = 7 mg/M^3) and BCME was not detected. Although crystalline silica was not detected in any of the personal air samples for pulp dust, its presence in the hi-vol air and settled dust samples suggests that sugar beet pulp dust is not biologically inert, but rather that it can potentially produce silicosis in exposed workers. None of the these exposures, during the processing of sugar beets, exceeded their respective OSHA standards.

During the June 1985 welding 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, 2.3 to 84 mg/M^3 (EC = 5.0 mg/M^3); insoluble hexavalent chromium, 0.003 to 0.426 mg/M^3 (EC = 0.001 mg/m^3); nickel, 0.002 to 4.17 (EC = 0.015 mg/M^3); iron oxide, 0.2 to 20 mg/M^3 (EC = 5.0 mg/M^3); manganese oxide, 0.01 to 1.7 mg/M^3 (EC = 1.0 mg/M^3); and total chromium, trace to 4.8 mg/M^3 (EC = 0.5 mg/M^3). Other compounds or elements detected but at levels below their respective most stringent EC included aluminum oxide, barium, calcium oxide, cadmium, lead, magnesium oxide, strontium, and zinc oxide. No other elements were detected. Concentrations of total welding fumes were above the OSHA standard. Additionally, one employee was exposed to airborne concentrations of total chromium, iron oxide, manganese oxide, and nickel in excess of their respective OSHA standards while using a plasma torch to remove paint from the inside surface of the diffuser.

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

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

II. INTRODUCTION

On October 15, 1984, the National Institute for Occupational Safety and Health (NIOSH) received a joint request from the management of American Crystal Sugar Company (ACSCo) and the American Federation of Grain Millers International Union (AFGM), to evaluate employee exposures to several chemical substances used or generated in the processing of granulated sugar and other sugar products from sugar beets at all five sugar beet mills owned and operated by ACSCo. Additionally, NIOSH was requested to evaluate employee exposures to welding fumes generated during intercampaign (off-season) maintenance activities. This report covers the facility in Crookston, Minnesota. The other four processing plants were located in Moorhead, Minnesota (HETA 85-018), East Grand Forks, Minnesota (HETA 85-044), Drayton, North Dakota (HETA 85-046), and Hillsboro, North Dakota (HETA 85-043). Separate final reports have been prepared for the environmental surveys conducted in each of these plants.

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

On January 15-16, 1985, NIOSH investigators conducted an industrial hygiene evaluation at the ACSCo plant in Crookston, Minnesota to evaluate employee exposures to a variety of air contaminants during campaign (sugar processing) activities. In November 1985, an interim report which presented the environmental findings and preliminary recommendations of the January survey, was transmitted to all interested parties.

On June 18-19, 1985, a follow-up environmental survey was conducted to evaluate employee exposures to welding fumes during intercampaign maintenance activities. The results of the intercampaign welding survey were transmitted to all interested parties via letter in February 1986.

III. BACKGROUND

A. Plant Production and Workforce

The American Crystal Sugar Company (ACSCo) is a cooperative, owned by approximately 1700 sugar beet growers, and has its 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 Crookston facility was built in 1954 and employs approximately 375 workers. Production operations are run three shifts per day, seven days a week, throughout the 6 month beet slicing campaign period which lasts from about mid September to about mid March.

During the intercampaign period (off-season) approximately 175 of the 375 workers are retained on a one-shift 6-day schedule to repair and maintain equipment throughout the facility.

During the beet slicing season the Crookston plant processes nearly 4700 tons of sugar beets a day, which are grown on about 55,000 acres of land in 5 surrounding counties. On the average, approximately 625 tons of sugar are produced each day of the 180 day campaign period. The average daily output of beet molasses and beet pulp, the by-products of the refining process, approximates 230 and 260 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 pieces called "cossettes". The cossettes are conveyed into the bottom of a large inclined cylindrical vessel called the diffuser. Hot water, flowing concurrent to the upward movement of the cossettes, is used to extract the sugar via osmosis. The processed cossettes (beet pulp), now devoid of most of the sugar, are dried in a large coal fired rotary drying drum, then are made into pellets for use as livestock feed. The sugar solution leaves the diffuser in the form of "raw juice".

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

C. Potential Sources of Exposures

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

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

IV. EVALUATION DESIGN AND METHOD

A. Campaign (Sugar Production)

On January 15 and 16, 1985, personal breathing zone and/or general area air samples were collected to characterize employee exposures to calcium oxide dust, calcium carbonate dust, pulp dust, coal dust, fly ash, crystalline silica, sugar dust, formaldehyde, hydrochloric acid (HCL), and bischloromethylether (BCME). Since several of the particulate materials being evaluated potentially contained crystalline silica, bulk samples and/or settled rafter dust samples were collected for qualitative and quantative crystalline silica analyses. Additionally, total and respirable high volume (hi-vol) samples were collected in 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 the presence of silica polymorphs (i.e. quartz and cristobalite). The settled dust and hi-vol samples were analyzed prior to analysis of personal air samples. The settled dust samples collected for silica analysis included beet pulp dust, coal dust, fly ash, coke dust, limestone, and the product Harborlite®. Results of these analyses were used to further determine which, if any, of the personal samples collected for the various dusts were to be analyzed for silica.

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

Lime kiln employees, including the lime kiln operator, the lime kiln helper, the slaker operator, and the rock shovel operator were monitored for total particulate exposure. Total particulate samples were collected from each worker and analyzed gravimetrically. Lime kiln workers were potentially exposed to calcium oxide and calcium carbonate dust. Employees working inside in the vicinity of the lime kiln were exposed to calcium oxide and the rock shovel operator was exposed to calcium carbonate. One general area sample for respirable particulates was also collected at the lime kiln operator's station.

The employee responsible for maintaining the pulp dryers was monitored for exposure to respirable coal dust and respirable particulates, one sample was collected each day. These samples were held for crystalline silica analysis, pending the results of the bulk samples.

Respirable particulate samples were collected from workers potentially exposed to sugar beet pulp dust. These included the pellet mill operator and employees working at the shredded pulp bagging station. One sample was collected from each worker each day. Further analysis of these samples for crystalline silica was dependent upon its presence in the settled rafter dust samples.

Total dust air samples were collected from employees potentially exposed to sugar dust, this included two Weibul maintenance mechanics, one Weibul housekeeper, and a two sugar sackers at the 100 pound bagging station. All samples were analyzed gravimetrically for total sugar dust.

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

Because formaldehyde and HCl are used in the sugar manufacturing process there was a concern that BCME, a recognized animal and human carcinogen, could be formed from the interaction of these two substances, especially since its presence has been documented by NIOSH investigators[1] in a similar sugar beet plant where formaldehyde and HCl were also used. To address this concern, general area air samples were collected for HCl, formaldehyde and BCME from areas or process equipment where formaldehyde and HCL were likely to be present. Additionally, personal air samples for formaldehyde were collected from the diffuser operator and the employee responsible for charging the diffuser with paraformaldehyde.

B. Intercampaign (Welding)

On June 18 and 19, 1985, workers were evaluated for exposure to welding fumes of various metals. The type of welding techniques observed during this survey included shielded metal arc welding, metal inert gas (MIG) welding, and air arc welding, on stainless, galvanized, and carbon steel. Plasma and oxyacetylene cutting were also performed. Air sampling and analytical methodologies for the sampled substances are presented in Table 2.

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

V. EVALUATION CRITERIA

A. Environmental Evaluation Criteria

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

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

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

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

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

B. Health Effects of Specific Compounds

1. Sugar dust [3]

Available toxicity data indicates that sugar dust would be characterized as a "nuisance" particulate. 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. Formaldehyde[5,6,7]

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

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

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

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

The health effects associated with exposure to welding fumes is dependant on the toxicity of individual component metals. This classification applies to welding environments where concentrations of toxic metals (i.e., chromium, cadmium, zinc) are not in excess of their respective exposure criteria.

Usually in these situations the major component of the fume is iron oxide or aluminum oxide, depending on whether the base metal is carbon (mild) steel or aluminum. Oxides of these metals are considered nuisance particulates based on their 5mg/M^3 criteria.

4. Iron oxide fumes[3,6,7]

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 give x-ray shadows that may be indistinguishable from fibrotic pneumoconiosis. Eight of 25 welders exposed chiefly to iron oxide for an average of 18.7 (range 3 to 32) years had reticulonodular shadows on chest x-rays consistent with siderosis but no reduction in pulmonary function; exposure levels ranged from 0.65 to 47 mg/M^3. In another study, 16 welders with an average exposure of 17.1 (range 7 to 30 years also had x-rays suggesting siderosis and spirograms which were normal; however, the static and functional compliance of the lungs was reduced; some of the welders were smokers. The welders with the lowest compliance complained of dyspnea.

5. Nickel [7,8]

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

VI. RESULTS AND DISCUSSION

A. Campaign (Sugar Production)

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

Table 4 presents the results of the crystalline silica analyses in the bulk dust and settled rafter dust samples. Quartz was detected in two sugar beet pulp dust samples and shown to be present at concentrations of 21% by weight in both samples. Neither of these samples contained detectable quantities of cristobalite (less than 0.75%, by weight). The results of the crystalline silica analysis on coal dust and coke dust rafter samples showed trace quantities of quartz between the analytical limit of detection (LOD) and the analytical limit of quantitation (LOQ) and are therefore considered to be semi-quantitative data. Cristobalite was not detected in either of the samples. Quartz and cristobalite were not detected in bulk samples of limestone and the Harborlite® filter aid.

Table 5 presents the results of hi-vol general area air samples collected for respirable and total particulates, and crystalline silica (% quartz). These samples were collected in the vicinity of the pellet mill, the lime kiln, and the pulp dryer. Results show that airborne quartz was detected in both respirable and total air samples collected in the pellet mill. Quartz was present in respirable particulate samples at concentrations of 1.8% and 1.1% and at concentrations of 2.4%

and 5.0% in total particulate samples. Cristobalite was not detected in any of these samples. Hi-vol samples collected in the lime kiln showed no detectable concentrations of quartz or cristobalite. Hi-vol samples collected at the pulp dryer showed trace quantities of quartz in the respirable particulate sample and 1.7% quartz in the total particulate sample. Cristobalite was not detected in any of these samples.

2. Personal Breathing Zone and General Area Air Samples

Environmental sampling results for each of the sampled substances are presented in Tables 6-13, along with the applicable environmental criteria.

Sample results for total particulates at the lime kiln are presented in Table 6. Total particulate concentrations in 7 personal samples ranged from 4.9 to 11.2 mg/M^3. Although exposures did not exceed the OSHA PEL of 15 mg/^{3}, the lime kiln helpers' exposure did exceed the ACGIH TLV of 10 mg/M^3. One general area air sample for respirable particulate was collected at the lime kiln operators station. This sample showed a concentration of 1.4 mg/M^3 which is below the ACGIH TLV and the OSHA PEL of 5.0 mg/M^3.

Air sampling results for respirable coal dust and respirable particulates associated with the pulp dryer are presented in Table 7. On the first day of sampling the pulp dryer coal man had a respirable coal dust exposure of 0.8 mg/M^3, which is below the American Conference of Governmental Industrial Hygienists (ACGIH) TLV and the Occupational Safety and Health Administration (OSHA) PEL of 2.0 and 2.4 mg/M^3, respectively. The second day of sampling this employee spent only about one hour in the pulp dryer area and the remainder of his day was spent at the shredded pulp bagging station and showed a concentration of 0.5 mg/M^3. Since his exposure would have been a mixture of coal dust and sugar beet pulp dust it is compared to the ACGIH TLV and the OSHA PEL of 5.0 mg/M^3 for nuisance dusts. These two samples were analyzed for crystalline silica and showed no detectable quantities of either quartz or cristobalite.

Results of personal samples collected for respirable pulp dust and crystalline silica in the pellet mill and the shredded pulp bagging station are presented in Table 8. Respirable sugar beet pulp dust concentrations ranged from 0.1 to 0.4 mg/M^3. Because crystalline silica was detected in the settled rafter dust samples and hi-vol general area air samples, all of these personal samples were analyzed for crystalline silica. All of these samples showed non-detectable concentrations of quartz and cristobalite (less than 0.015 mg/M^3). Because the personal samples did not contain detectable quantities of quartz, the respirable dust concentrations are comparable to the ACGIH TLV and the OSHA PEL of 5.0 mg/M^3 for nuisance particulates.

Results of personal samples collected for sugar dust, as total particulate, near the breathing zone of the Weibul maintenance mechanics, the Weibul housekeepers, and the sugar sacker are presented in Table 9. Concentrations ranged from 0.5 to 13.4 mg/M^3. Only one sample (the Weibul housekeeper) exceeded the ACGIH TLV of 10 mg/M^3 and none exceeded the OSHA PEL of 15 mg/M^3.

Respirable amorphous silica sample results for the juice filtration operators are presented in Table 10. The U.S. filter operator had exposures of 1.3 and 1.1 mg/M^3, and the Industrial filter operator had exposures of 0.1 and 0.3 mg/M^3. Since the bulk sample of the Harborlite® filter aid did not contain detectable levels of quartz or cristobalite these samples results are comparable to the ACGIH TLV and OSHA PEL for nuisance dusts of 5.0 mg/M^3.

Table 11 presents the results of personal breathing zone air sampling for formaldehyde. Two of the three samples collected showed detectable levels of formaldehyde. The first day of sampling, the diffuser operator had an exposure of 0.05 mg/M^3, but showed no detectable concentration the second day. A second employee responsible for charging the diffuser with paraformaldehyde was monitored and was exposed to a concentration of 0.09 mg/M^3. These exposures were below the ACGIH TLV and the OSHA PEL of 1.2 and 3.7 mg/M^3, respectively. NIOSH, however, recommends that exposures be reduced to the lowest feasible level since formaldehyde is considered to be a suspect human carcinogen.

Table 12 presents the results of the general area air sampling for formaldehyde, HCL, and BCME. Formaldehyde was detected in three of the five air samples. HCl was detected in four of the five samples, and BCME was not detected in any of the samples. Two of the five samples showed formaldehyde and HCl to be present at the same station, however BCME was not detected. Formaldehyde concentrations ranged from 0.05 to 0.25 mg/M^3 and HCl concentrations ranged from 0.02 to 0.06 mg/M^3.

B. Intercampaign (Welding)

Air sampling results from the June 1985 welding survey 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.

Airborne concentrations of total welding fumes ranged from 2.3 to 84 mg/M^3, with 12 of 17 air samples exceeding the OSHA PEL of 5.0 mg/M^3. Specific metals or compounds measured at concentrations above their respective action level included hexavalent chromium (Cr VI), total chromium, iron oxide, manganese, and nickel. Two of 9 air samples analyzed for insoluble Cr VI could not be quantified because of interfences present in the samples. In the seven samples where Cr VI was quantifiable, airborne concentrations were measured at levels ranging from 0.003 to 0.426 mg/M^3. All seven quantifiable samples exceeded the NIOSH REL of 0.001 mg/M^3 for Cr VI, two exceeded the ACGIH TLV of 0.05 mg/M^3 but, none exceeded the OSHA PEL of 0.5 mg/M^3. Total chromium concentrations ranged from trace quantities to 4.8 mg/M^3. Two of 17 samples exceeded the ACGIH TLV of 0.5 mg/M^3 and one exceeded the OSHA PEL of 1.0 mg/M^3. Iron oxide concentrations ranged from 0.2 to 20 mg/M^3. Only one of seventeen samples exceeded the OSHA PEL and the ACGIH TLV of 5.0 mg/M^3. Manganese concentrations ranged from 0.01 to 1.7 mg/M^3. Only one of the seventeen samples exceeded the ACGIH TLV of 1.0 mg/M^3 and none exceeded the OSHA PEL of 5.0 mg/M^3. Nickel concentrations ranged from 0.002 to 4.17 mg/M^3. Eight of 17 samples exceeded the NIOSH REL of 0.015 mg/M^3 while only one exceeded the OSHA PEL and the ACGIH TLV of 1.0 mg/M^3.

One sample collected the morning of June 18 from 7:10 to 8:44 a.m., is of particular concern. This sample had the highest concentration of all total welding fume and the highest concentration of all metals listed in Table 13. The sample was collected from an employee using a plasma torch to burn paint off the inside of the diffuser prior to welding.

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

VII. DISCUSSION AND CONCLUSION

A. Campaign (Sugar Production)

The environmental sampling results presented in this report show that the lime kiln helper was overexposed to total particulates, that the Weibul housekeeper was overexposed to sugar dust, and that the diffuser operator and the employee responsible for charging the diffuser with paraformaldehyde were overexposed to formaldehyde.

Although crystalline silica was not detected in respirable dust samples collected from the workers at the shredded pulp bagging station, the presence this material in the high volume general area air samples and the settled rafter dust samples collected in the pellet mill indicate that sugar beet pulp dust does contain crystalline silica, therefore, appropriate precautions should be taken.

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

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

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

B. Intercampaign (Welding)

The results of the environmental sampling indicate that workers engaged in welding and cutting operations were overexposed to airborne concentrations of total welding fumes and/or various metals. Overexposures to insoluble hexavalent chromium (Cr VI) and nickel are of particular concern since these two substance have been associated with the development of nasal and/or lung cancer in humans.

The highest exposures to welding fumes were measured in samples obtained from workers welding in confined space work environments (inside the diffuser and inside the pulp dryer). All ten samples (one was not analyzed) collected from employees working in these confined space environments showed excessive concentrations of total welding fumes and 6 of 11 showed excessive concentrations of nickel. Seven of the nine samples analyzed for Cr VI showed excessive concentrations of Cr VI, the other two could not be analyzed due to the presence of interferences in the samples. Although portable local exhaust ventilation (LEV) systems were available to workers, they were used infrequently during our evaluation. This reportedly stemmed from the fact that the flexible ducting on the systems was not long enough to reach the piece being welded in many cases. Additionally, none of the workers was observed wearing respiratory protection. Welders working in other areas of the facility in non-confined work settings did not use LEV systems nor did they use respirators to protect themselves from generated contaminants.

The extent of the welding fume exposures (approximately 81% of the personal samples exceeded the most stringent occupational exposure criteria for total welding fume and/or one or more metals), and the fact that potential human carcinogens were present in all samples collected on employees working inside the diffuser underlie the need for effective control measures to minimize worker exposures.

VIII. RECOMMENDATIONS

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

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

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

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

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

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

6. In situations where the use of LEV systems is 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.

7. Special precautions should be taken when using the plasma torch to burn old paint off of surfaces. As evidenced from the sample results, this operation tends to generate larger quantities of contaminants and would presumably be dependent upon the composition of the paint and/or metal surface. The recommendations listed in 5 and 6 should be followed as necessary.

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

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

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

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

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

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

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

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

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XI. DISTRIBUTION AND AVAILABILITY OF DETERMINATION REPORT

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

1. American Crystal Sugar Company, Crookston Plant
2. American Crystal Sugar Company, Corporate Office
3. American Federation of Grain Millers, Minneapolis, Minnesota
4. American Federation of Grain Millers, Local #267
5. U.S. Department of Labor, OSHA - Region V

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

Table 1

Potential Exposures during Campaign (Sugar Processing)

American Crystal Sugar Company
Crookston, Minnesota
HETA 85-045

January 15-16, 1985

Location	Job Classifications of Monitored Workers	Potential Contaminant(s)	Source(s) of Contaminants
Lime kiln/limestone stockpile	Lime kiln operator, lime kiln helper, rock shovel operator	Calcium oxide, calcium carbonate	CaO is produced in the lime kiln from oxidation of calcium carbonate; generated primarily from open track conveyor system at base of lime kiln. CO is incomplete combustion product from conversion of $CaCO_3$ to CaO.
Diffuser and carbonation area	Utility man, stationary air samples	Formaldehyde, hydrochloric acid, bischloromethyl ether	Formaldehyde, piped into the diffusers to control bacteria, may be present as a vapor at the discharge pulp conveyor at the top of the diffusers. Dilute hydroclofic 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 and shredded pulp bagging station	Pellet mill operator, mechanic, and pulp bagging station	Beet pulp dust, crystalline silica	Pellet machines, pellet transfer equipment such as conveyors, front end loaders; housekeeping activities.
Boiler and pulp dryer areas	Coal and ash handlers	Coal dust, fly ash crystalline silica	Unloading of coal from rail cars, maintenance and housekeeping activities.
Carbonation area	U.S. filter and industrial filter operators	Amorphous silica	Manual bag changing of Harborlite® and Dicalite® into receiving hoppers.
Sugar silos/bins; sugar sacking stations	Sugar bin cleaners and operators; and sackers	Sugar dust (total)	Loading sugar into rail cars, bagging sugar, housekeeping activities.

Table 2

Sampling and Analysis Methodology

American Crystal Sugar Company
Crookston, Minnesota
HETA 85-045

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

Table 3

Evaluation Criteria and Health Effects Summary

American Crystal Sugar Company
Crookston, Minnesota
HETA 85-045

Substance	Evaluation 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
Calcium carbonate (limestone) dust	-	15.0	10.0	Considered a nuisance particulate. Excessive concentrations of nuisance particulate may cause unpleasant deposits in the eyes, ears, and nasal passages, and may seriously reduce workroom visibility.	3,4
Calcium oxide dust (total)	-	5.0	2.0	Causes irritation of the eyes, mucous membranes, and skin. Dust inhalation may cause ulceration and perforation of nasal system.	3,4,6
Chromium hexavalent (insoluble)	0.001	0.5	0.05	Lung cancer, skin ulcers and lung irritation.	2,3,4,13
Chromium (total)	-	1.0	0.5	Severe upper respiratory tract irritation, nasal ulceration.	3,4,6
Coal dust (< 5% quartz)	-	2.4	2.0	Coal workers' pneumoconiosis.	3,7,
Coal dust (> 5% quartz)	-	Crystalline silica formula			
Crystalline silica (respirable)	0.05	$\frac{10\ mg/M3}{\%\ SiO_2+2}$	$\frac{10\ mg/M3}{\%\ SiO_2+2}$	Silicosis; a pneumoconiosis due to the inhalation of silicon dioxide-containing dust, which is a disabling, progressive and sometimes fatal pulmonary fibrosis characterized by the presence of typical nodulation in the lungs.	2,3,14

(Table 3 continued on next page)

Table 3 (continued)

Substance	Evaluation Criteria[1] (mg/M³) NIOSH REL	OSHA PEL	ACGIH TLV	Primary Health Effects	References
Fly ash[2] (respirable)	-	5.0	5.0	Regulated as a nuisance particulate. Excessive concentrations of nuisance dusts may cause unpleasant deposits in the eyes, ears, and nasal passages, and may seriously reduce workroom visibility. When crystalline silica content in bulk samples is less than 1%.	3,4
Formaldehyde	lowest level feasible	3.7 (3.0 ppm)	1.2(c) (1.0 ppm)	Vapors can cause irritation of the eyes & upper respiratory tract. Animal carcinogen. Contact with the liquid can cause both primary irritation and sensitization dermatitis.	2,3,4,5
Hydrochloric acid (HCL)	7.0 5 ppm	7.0 5 ppm	7.0(c) 5 ppm	A strong irritant of the eyes, mucous membranes, and skin.	2,3,4,15
Iron oxide (as Fe)	---	5.0	5.0 (10.0 STEL)	Siderosis - a benign pneumoconiosis or respiratory condition associated with inhalation of particulates.	3,4,15
Manganese	---	5.0(C)	1.0 (3.0 STEL)	Manganism - central nervous system effects of chronic intoxication; metal fume fever.	3,4,7
Nickel inorganic (as Ni)[3]	0.015	1.0	1.0	Respiratory irritation from fume, skin effects; lung and nasal cancer.	2,3,4,8
Sugar Beet Pulp Dust (respirable)[2]	-	5.0	5.0	Regulated as a nuisance particulate. Refer to health effects described for fly ash.	3,4,7
Sugar dust (total)	-	15.0	10.0	Same as above.	
Welding fumes (N.O.C.)	-	5.0	5.0	Toxicity of component metal must be considered individually.	3,4,6

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

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

Table 4

Crystalline Silica Content in Bulk and Settled Rafter Dust Samples

American Crystal Sugar Company
Crookston, Minnesota
HETA 85-045

January 15-16, 1985

Substance	Crystalline silica (% by wt.) Quartz	Cristobalite
Beet pulp dust - pellet mill rafter samples	21	<0.75
Beet pulp dust - pellet mill rafter samples	21	<0.75
Coal dust - pulp dryer rafter sample	(1.0)*	<0.75
Limestone	<0.75	<0.75
Coke - lime kiln rafter sample	(1.0)*	<0.75
Harborlite® (amorphous silica) - bulk sample	<0.75	<0.75

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

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

Table 5

High Volume Air Samples for Total and Respirable Crystalline Silica

American Crystal Sugar Company
Crookston, Minnesota
HETA 85-045

January 15-16, 1985

Date	Location	sample time (minutes)	sample volume (liters)	particulates (mg/M^3)	Quartz (mg/M^3)	% Quartz
			Pulp Dust			
1/15/85	Pellet mill (Resp.)	143	1258	1.80	0.032	1.8 *
1/15/85	Pellet mill (Total)	143	1244	5.09	0.121	2.4 *
1/15/85	Pellet mill (Resp.)	239	2103	4.38	0.048	1.1 *
1/15/85	Pellet mill (Total)	239	2079	8.66	ND	5.0 *
			Calcium Oxide			
1/16/85	Lime kiln - pit (Resp.)	123	1082	5.25	ND	ND*
1/16/85	Lime kiln - pit (Total)	123	1070	25.49	ND	ND*
			Coal Dust			
1/16/85	Pulp dryer, 2nd level (Resp.)	128	1126	2.07	(0.018)	(0.9)*
1/16/85	Pulp dryer, 2nd level (total)	128	1114	4.85	0.081	1.7 *

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

Table 6

Personal Breathing Zone Concentrations of Total Particulates and General Area Air Concentrations of Calcium Oxide Associated with the Lime Kiln

American Crystal Sugar Company
Crookston, Minnesota
HETA 85-045

January 15-16, 1985

Date	Job/Location	sample time (minutes)	sample volume (liters)	Airborne Concentrations (mg/M^3) Respirable Particulates	Total Particulates
1/15/85	Lime kiln operator	488	732	--	4.9*
1/16/85	Lime kiln operator	476	714	--	6.8*
1/16/85	Area Sample @ Lime operators station	469	938	1.4	--
1/15/85	Lime kiln helper	480	720	--	9.6*
1/16/85	Lime kiln helper	497	746	--	11.2*
1/16/85	Lime kiln slaker	472	708	--	8.2*
1/15/85	Rock shovel operator	474	711	--	5.0
1/16/85	Rock shovel operator	468	702	--	6.8
Environmental Criteria:			ACGIH-TLV	5.0	10.0
			OSHA-PEL	5.0	15.0

Abbreviations: mg/M^3 - milligrams of CaO or $CaCO_3$ per cubic meter of air
*These values are most likely a combination of calcium carbonate ($CaCO_3$) and calcium oxide (CaO)

Table 7

Respirable Coal Dust and Respirable Particulate Exposures of the Pulp Dryer Coal Man

American Crystal Sugar Company
Crookston, Minnesota
HETA 85-045

January 15-16, 1985

Date	Job/Location	sample time (minutes)	sample vol. (liters)	Airborne Concentrations (mg/M^3) Coal Dust	Respirable Particulates	Quartz
1/15/85	Pulp dryer - coal man	491	982	0.8	--	ND
1/16/85	Pulp dryer - coal man*	478	956	--	0.5	ND
Environmental Criteria:		NIOSH		--	--	0.05
		ACGIH-TLV		2.0	5.0	0.10
		OSHA-PEL		2.4	5.0	--

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

* - employee spent only about 1 hour in coal handling area, rest of time spent at shredded pulp station.

Table 8

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

American Crystal Sugar Company
Crookston, Minnesota
HETA 85-045

January 15-16, 1985

Date	Job/Location	sample time (minutes)	sample vol. (liters)	Airborne Concentrations (mg/M^3)	
				Pulp Dust	Quartz
1/15/85	Pellet mill operator	491	834	0.4	ND
1/16/85	Pellet mill operator	483	821	0.2	ND
1/15/85	Shredded pulp bagger	467	794	0.1	ND
1/16/85	Shredded pulp bagger	492	836	0.2	ND
1/15/85	Shredded pulp bagger	467	794	0.2	ND
1/16/85	Shredded pulp bagger	475	808	0.4	ND
1/15/85	Shredded pulp bagger	461	830	0.2	ND
1/16/85	Shredded pulp bagger	476	809	0.1	ND
1/16/85	Warehouse loading bags of shredded pulp	419	712	0.3	ND
Environmental Criteria:		NIOSH		--	0.05
		ACGIH-TLV		5.0*	0.10
		OSHA-PEL		5.0*	--

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

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

Table 9

Personal Breathing Zone Air Concentrations of Sugar Dust

American Crystal Sugar Company
Crookston, Minnesota
HETA 85-045

January 15 - 16, 1985

Date	Job/Location	sample time (minutes)	sample volume (liters)		Sugar Dust Airborne Concentration mg/M3
1/15/85	Weibul maintenance mechanic	495	742		2.3
1/16/85	Weibul maintenance mechanic	499	748		5.1
1/15/85	Weibul maintenance mechanic	459	688		3.4
1/16/85	Weibul maintenance mechanic	487	730		2.0
1/16/85	Weibul housekeeper	476	714		13.4
1/16/85	Sugar sacker, 100 lb. station	419	628		1.0
1/16/85	Sugar sacker, 100 lb. station	417	626		0.5
Environmental Criteria:				ACGIH-TLV	10.0
				OSHA-PEL	15.0

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

Table 10

Respirable Amorphous Silica Exposures of Filter Operators

American Crystal Sugar Company
Crookston, Minnesota
HETA 85-045

January 17-18, 1985

Date	Job/Location	sample time (minutes)	sample volume (liters)	Airborne Concentration Amorphous silica* (mg/M^3)
1/15/85	US filter operator	495	842	1.3
1/16/85	US filter operator	484	823	1.1
1/15/85	Industrial filter operator	488	830	0.1
1/16/85	Industrial filter operator	498	847	0.3
Environmental Criteria:			NIOSH	-4-
			ACGIH-TLV	5.0
			OSHA-PEL	5.0

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

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

Table 11

Personal Breathing Zone Air Concentrations of Formaldehyde

American Crystal Sugar Company
Crookston, Minnesota
HETA 85-045

January 15 - 16, 1985

Date	Job/Location	sample time (minutes)	sample volume (liters)	Airborne Concentration (mg/M^3)	(ppm)
1/15/85	Diffuser operator	499	41.0	0.05	0.04
1/16/85	Diffuser operator	139	0.6	Not Detected	
1/16/85	Employee charged 5 bags paraformaldehyde	471	36.8	0.09	0.07
Environmental Criteria:			NIOSH	Lowest Feasible Limit	
			ACGIH-TLV	1.2	1.0
			OSHA-PEL	3.7	3.0

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

Table 12

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

American Crystal Sugar Company
Crookston, Minnesota
HETA 85-045

January 15-16, 1985

Date	Location	Sample time (minutes)		Airborne Concentration (mg/M^3) Formaldehyde	HCl	BCME
1/15/85	Diffuser operator station	467		0.05	0.02	ND
1/15/85	Knife station, near pulp conveyor	438		ND	0.02	ND
1/15/85	Picker station	434		ND	0.06	ND
1/16/85	Paraformaldehyde tank	443		0.23	0.03	ND
1/16/85	Catwalk above the diffuser	449		0.25	ND	ND
Environmental Criteria:			NIOSH	LFL	7	LFL
			ACGIH-TLV	1.2	7-C	0.005
			OSHA-PEL	3.7	7-C	Regulated carcinogen

Abbreviations:
ppm - parts of hydrochloric acid per million parts of air

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

Personal Air Sampling Results for Welding Fumes

American Crystal Sugar Company
Crookston, Minnesota
HETA 85-045

June 18-19, 1985

				Environmental Concentration (mg/M3)					
Date	Location/Job	Sampling† Duration	Sample Volume (liters)	Total Welding Fume	Hexavalent Chromium	Total Chromium	Iron Oxide	Manganese	Nic
6-18	Inside diffuser	0700-1514	430	31	0.1070				
			813			0.70	1.5	0.52	0.1
6-19	" "	0702-1515	493	13	**				
			740			0.49	2.2	0.20	0.3
6-18	" "	0706-1513	396	5.4	NA				
			660			0.02	1.1	0.02	0.0
6-19	" "	0707-1516	494*	--	--				
			692			0.01	1.4	0.13	0.0
6-18	" "	0710-0844††	94	84	0.426				
			132			4.8	20	1.7	4.1
		0930-1512	283	14	0.012				
			396			0.33	1.0	0.35	0.0
6-19	" "	0700-1515	464	8.4	**				
			696			0.11	1.9	0.14	0.0
6-18	" "	0708-1515	370	12	NA				
			699			0.02	1.1	0.04	0.0
6-19	" "	0704-1443	412	11	NA				
			618			0.02	1.9	0.16	0.0
6-18	Inside pulp dryer, repairing induced draft fan	0712-1524	482	24	NA				
			675			0.22	4.4	0.12	0.3
6-19	" " "	0706-1526	414	5.0	NA				
			621			0.01	0.6	0.01	0.0

(Table 13 continued on next page)

(Table 13 continued)

Date	Location/Job	Samplingt Duration	Sample Volume (liters)	Environmental Concentration (mg/M³) Total Welding Fume	Hexavalent Chromium	Total Chromium	Iron Oxide	Manganese	Nick
6-18	Disintegrator screen house, building new disintegrator	0719-1521	437	2.5	0.018				
			778			0.07	0.2	0.07	0.02
6-19	" " "	0703-1520	497	8.0	0.003				
			746			0.01	1.5	0.15	0.00
6-18	Intermediate centrificals, making repairs	0716-1521	442	2.3	0.011				
			687			0.03	0.2	0.02	0.00
6-19	" "	0710-1525	360	4.2	0.014				
			504			0.18	0.5	0.14	0.05
6-18	Pulp dryer, relining exterior of discharge end	0719-1047	208	9.0	NA				
			333			0.01	1.2	0.05	0.00
6-19	" " "	0716-1531	501*	--	--				
			752			trace	0.8	0.02	0.00
Environmental Criteria:		NIOSH		---	0.001	---	---	---	0.01
		ACGIH		5.0	0.05	0.5	5.0	1.0	1.0
		OSHA		5.0	0.5	1.0	5.0	5.0	1.0

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

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

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

APPENDIX

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

American Crystal Sugar Company
Crookston, Minnesota
HETA 85-045

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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