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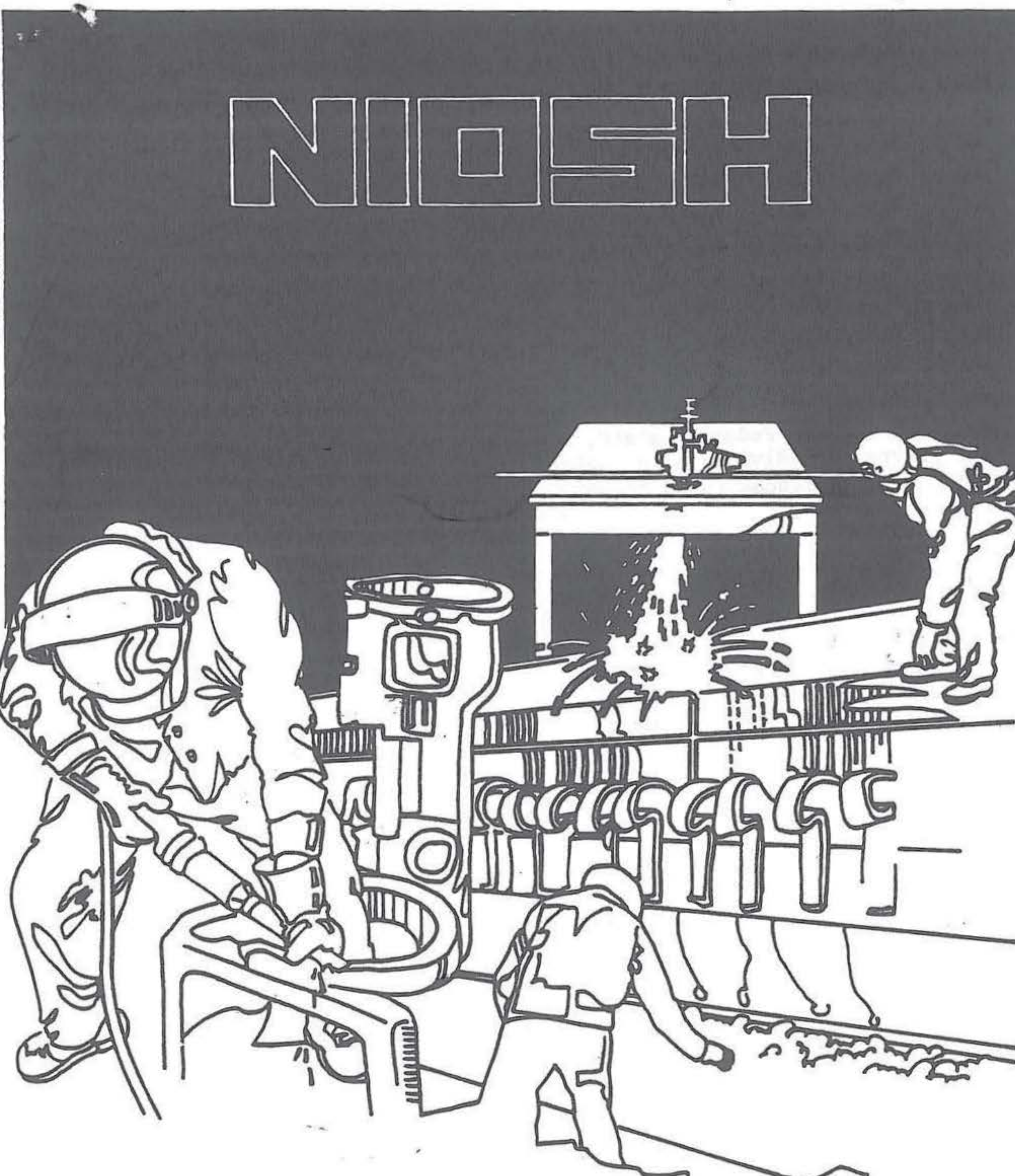

Health Hazard Evaluation Report

HETA 85-044-1761
AMERICAN CRYSTAL SUGAR COMPANY
DRAYTON, 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 85-044-1761
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AMERICAN CRYSTAL SUGAR COMPANY
DRAYTON, 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 Drayton, North Dakota. In addition, NIOSH was asked to evaluate employee exposures to welding fumes generated during ACSCo's summer maintenance operations.

On January 30 and 31, 1985, and on June 6 and 7, 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 sampling was conducted to characterize employee exposure to bischloromethylether (BCME), calcium oxide, carbon monoxide (CO), coal dust, crystalline silica, diatomaceous earth, fly ash, formaldehyde, gypsum, hydrochloric acid (HCl), sugar beet pulp dust, and total sugar dust. Bulk and/or settled dust samples were collected in areas where coke, limestone, pulp dust, coal and fly ash were present for characterization of crystalline silica content. Long-term general area air samples were collected for CO, BCME, formaldehyde, and HCl.

Analysis of the air samples revealed the following ranges of concentrations which are compared to their most stringent environmental criteria (EC): calcium oxide, 1.5 to 2.1 mg/m^3 (EC = 2.0 mg/M^3); CO, nondetectable (ND) to 5 ppm (EC = 35 ppm); coal dust, 0.5 to 9.0 mg/M^3 (EC = 2.0 mg/M^3); fly ash, 0.5 to 0.9 mg/M^3 (EC = 5.0 mg/M^3); diatomaceous earth, 0.2 to 0.7 mg/M^3 (EC = 5.0 mg/M^3); formaldehyde, 0.11 to 0.37 mg/M^3 (EC = lowest feasible level); HCl, 0.04 to 0.07 mg/M^3 (EC = 7 mg/M^3); pulp dust, 0.2 to 1.4 mg/M^3 (EC = 5.0 mg/M^3) and sugar dust, 0.1 to 11 mg/M^3 (EC = 10 mg/M^3). Crystalline silica was detected in only one sample, obtained from the coal handler, at a concentration of 0.089 mg/M^3 (EC = 0.050 mg/M^3). All air samples for BCME were nondetectable. Although crystalline silica was not detected in any of the personal air samples for pulp dust, its presence in the bulk samples suggests that sugar beet pulp dust is not biologically inert, but rather that it can potentially produce silicosis in exposed workers. Coal dust was the only substance to exceed the OSHA standard.

During the June survey, full-shift personal breathing-zone air samples were collected and analyzed for total welding fume, insoluble chromium, and 26 specific elements of toxicological importance. Environmental concentration ranges for total welding fumes, hexavalent chromium and for those other metals or compounds at concentrations greater than their respective most stringent EC as follows: total welding fumes, 0.9 to 19 mg/M^3 (EC = 5.0 mg/M^3); calcium oxide fume, 0.1 to 2.6 mg/M^3 (EC = 2.0 mg/M^3); total chromium, 0.1 to 1.2 mg/M^3 (EC = 0.5 mg/M^3); copper fume, ND to 0.11 mg/M^3 (EC = 0.10 mg/M^3); iron oxide fume, 0.6 to 21 mg/M^3 (EC = 5.0 mg/M^3); nickel, ND to 1.2 mg/M^3 (EC = 0.015 mg/M^3); and insoluble Cr VI, 0.0004 to 0.0037 mg/M^3) (EC = 0.001 mg/M^3). Only 2 of 11 air samples for insoluble hexavalent chromium could be quantified due to the presence of interfering metals in the samples. Despite this limitation, we feel that the presence of Cr VI in the remaining 9 air samples was very likely, especially considering that it was detected in most of the air samples we collected from workers at the other ACSCo plants, where interferent metals were less of a problem. No other elements were detected. Concentrations of total welding fumes, iron oxide, nickel, total chromium, and copper fume exceeded their respective OSHA standards.

On the basis of the data obtained during this investigation, it has been determined that workers at ACSCo's Drayton plant were overexposed to calcium oxide, coal dust, crystalline silica, sugar dust and formaldehyde during sugar production, and to total welding fumes, total and hexavalent chromium, copper, iron oxide and nickel 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 oxide dust and fume, coal dust, crystalline silica, sugar dust, formaldehyde, welding fumes, chromium, nickel copper, iron oxide, 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 Drayton, North Dakota. The other four processing plants were located in Crookston (HETA 85-045), East Grand Forks (HETA 85-046), Moorhead, Minnesota (HETA 85-018), and in 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 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 30 and 31, 1985, we evaluated employee exposures to a variety of air contaminants during campaign (sugar processing) activities at the Drayton 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 6 and 7, 1985, we returned to the facility during intercampaign maintenance activities and evaluated worker exposures to welding fumes. The environmental findings and recommendations from this survey were presented to the company and union via two interim letters, issued in June and December 1985.

III. BACKGROUND

A. Plant 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 Drayton facility, built in 1965, is the newest of the five plants. The plant employs 370 workers and operates on three shifts, seven days a week throughout the 6 month beet slicing campaign period which lasts from mid-September to March.

During the off-season (intercampaign period), approximately 150 of the 370 production workers are retained on a one-shift 6-day schedule to repair/maintain various equipment throughout the facility.

During the campaign, the Drayton plant processes nearly 5200 tons of sugar beets a day, which are grown on approximately 46,000 acres of land in 5 surrounding counties. On the average, approximately 740 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 260 and 310 tons, respectively.

B. Process Description

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

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 oxide of $CaCO_3$ using coke as a fuel source) in carbonation vessels to precipitate impurities and non-sugars from the juice. The juice is then 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 and potential contaminant exposures and their sources by area, is provided in Table 1.

During the intercampaign period, approximately 10 to 15 maintenance workers were potentially exposed to metal fumes generated from welding operations.

The type of welding techniques observed during the survey included conventional shielded metal arc welding, metal inert gas (MIG) welding, and air arc welding, on stainless steel and/or carbon steel. Oxyacetylene cutting was also performed and evaluated during the survey.

IV. EVALUATION DESIGN AND METHODS

A. Campaign

On January 30 and 31, 1985, personal and/or general area air samples were collected to characterize employee exposures to carbon monoxide (CO), calcium oxide dust, pulp dust, crystalline silica, coal dust, fly ash, sugar dust, gypsum, diatomaceous earth, formaldehyde, hydrochloric acid (HCL), and bischloromethylether (BCME). Since most of the particulate materials under investigation potentially contained crystalline silica, we collected bulk samples and/or settled rafter dust samples for qualitative and quantitative crystalline silica analyses. Samples of limestone, beet pulp dust, fly ash, coal dust, coke, diatomaceous earth, and gypsum were also collected for this purpose. 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 incorporated in the exposure assessment for each of these substances is provided below.

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

Three air samples for CO were collected from the lime kiln workers over the two day period. In addition, stationary air samples were collected in the immediate vicinity of the CO_2 gas turbine and ancillary equipment.

Employees responsible for maintaining the coal-fired boilers and pulp dryers were monitored for exposure to coal dust or fly ash. Six workers were monitored including three boiler workers (coalman, ashman, and helper), two pulp dryer workers (coalman and ashman), and a coal handler. Two air samples were collected from each worker, one each day for a total of 12 air samples. Because there is no practical method for distinguishing between coal dust and fly ash on a particular sample, results were classified as either coal dust or fly ash exposures dependent upon the observed duties of the employee. All of these samples were held for crystalline silica analysis, pending the results of the bulk samples.

Respirable dust samples were collected from workers potentially exposed to beet pulp dust. These included the pellet mill operator and pulp loader. A total of four air samples were collected, one from each worker each day. Further analysis of these samples for crystalline silica was dependent upon its presence in the settled rafter dust samples.

Twelve total dust air samples were collected from employees potentially exposed to sugar dust including the Weibul housekeepers, bulk loaders, warehousemen, and a sugar bagger. All samples were analyzed gravimetrically for sugar dust.

Respirable dust samples were collected from the U.S. Filter operator and the diffuser operator to determine their exposure to diatomaceous earth (contained in Celite® filter aid) and gypsum, respectively. Two samples were collected from each worker during the two day survey.

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 four general area air samples for each of these substances from areas or process equipment where formaldehyde and HCl were likely to be present (i.e. top and bottom of diffuser, drum filter, and knife station area). Additionally personal air samples for formaldehyde were collected from the diffuser operator and diffuser watcher.

B. Intercampaign (welding)

On June 6 and 7, 1985, twenty-six 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. All of the welders utilized conventional arc welding techniques with the exception of one worker who used an air arc welder. Cutting operations were exclusively done with an oxyacetylene cutting torch. Base metals consisted of black, mild, and stainless steel. Air sampling and analytical methodologies for the sampled substances are presented in Table 2.

With respect to the workers wearing welding helmets, the filter cassettes were place high on the collar to insure their placement inside the helmet which would provide an air sample indicative of what the worker is breathing, since concentrations have been shown to be 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, 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 ECP-AES are presented in the Appendix.

V. Evaluation Criteria

A. Environmental Evaluation Criteria

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

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

The primary sources of 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 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 are presented in Table 3, along with a brief description of their primary health effects. For those substances found to be in excess of their most stringent criteria the following discussion is presented.

B. Health effects of specific compounds

1. Calcium oxide[5,6]

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

2. Coal dust[5,6]

The inhalation of coal dust causes coal worker's pneumoconiosis (CWP). Simple CWP has no clinically distinguishing symptoms and often occurs simultaneously with chronic bronchitis and emphysema. Although CWP is associated with several respiratory impairments, CWP is not associated with a shortening of life span; the significance of this benign condition is the fact that CWP is a precursor to progressive massive fibrosis (PMF).

Complicated pneumoconiosis or PWF is associated with a reduction in ventilatory capacity, low diffusing capacity, abnormalities of gas exchange, low arterial oxygen tension, pulmonary hypertension, and premature death. CWP may appear several years after exposure has ceased and may progress in the absence of further dust exposure. Obstructive airway disease is common in PMF, probably the consequence of the distortion and narrowing of the bronchi and bronchioles produced by the massive lesion.

3. Crystalline silica[7]

Crystalline silica or quartz dust causes silicosis; a form of disabling, progressive, and sometimes fatal pulmonary fibrosis characterized by the presence of typical nodulation in the lungs. The clinical signs and symptoms of silicosis tend to be progressive with continued exposure to quantities of dust containing free silica, with advancing age, and with continued smoking habits. Symptoms include cough, dypsnea, wheezing, and repeated nonspecific chest illnesses. Impairment of pulmonary function may be progressive. Progression of symptoms usually continues after dust exposure ceases. While there may be a factor of individual susceptibility to a given exposure to silica dust, the risk of onset and the rate of progression of the pulmonary lesion is clearly related to the concentration and duration of exposure. The disease tends to occur after an exposure measured in years rather than months. Occassionally, exposures to very high concentrations occur in short periods of time in occupations such as sandblasters and tunnel workers; in these cases of acute or rapidly-developing silicosis there may be severe respiratory symptoms resulting in death. It is generally accepted that silicosis predisposes the individual to active tuberculosis, and that the combined disease tends to be more rapidly progressive than uncomplicated silicosis.

4. Sugar dust[3]

Available toxicity data indicates that sugar dust is a "nuisance particulate". Nuisance dusts, in contrast to fibrogenic 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.

5. Formaldehyde[5,8]

The health effects of formaldehyde can result from acute or chronic exposure. The effects of acute expoosure 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, solutions or formaldehyde-containing resins has been documented. Formaldehyde is a primary skin irritant but may also cause allergic dermatitis at concentrations beloiw those likely to cause primary irritant 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 chacteriozed by redness, swelling, vesciculation and oozing with itching. In the chronic form, affected ares 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.

6. 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 [5,6,9]

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.

9. Nickel [5,6,10]

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.

10. Copper fume[5,6]

Inhalation of copper fumes may cause congestion of the nasal mucous membranes, and on occasions, ulceration with perforation of the nasal septum. Inhalation of copper fume results in irritation of the upper respiratory tract and an influenza-like illness termed metal fume fever. Signs and symptoms of metal fume fever include chills, muscle aches, nausea, fever dry throat, cough, weakness, and lassitude. Recovery is usually rapid. Most workers develop a tolerance to these attacks, but it is quickly lost; attacks tend to be more severe on the first day of the work-week. Other effects from copper fume exposure include metallic or sweet taste, and in some instances, discoloration of the skin and hair or dermatitis.

VI. Results

A. Campaign

1. Bulk samples and settled rafter dust samples

Table 4 presents the results of the crystalline silica analysis in the bulk dust and settled rafter dust samples. Quartz was detected in the samples of pulp dust, coal dust, and fly ash at concentrations of 1.9, 1.0 and 7.8% by weight, respectively. None of these samples contained detectable quantities of cristobalite (less than 0.75%, by weight). Quartz and cristobalite were not detected in bulk samples of limestone, coke, diatomaceous earth (Celite®), and gypsum (less than 0.75% for both analytes). Because an interference was present in the Celite®, the detection limit of the analysis for cristobalite was 5.0% instead of 0.75% by weight.

2. Personal and general area air samples

Environmental sampling results are presented in Tables 5-12, along with applicable environmental criteria.

Air sampling results for calcium oxide and respirable particulates are presented in Table 5. Calcium oxide exposures of the lime kiln operator and the slaker operator were measured at 1.5 and 2.1 mg/M^3, respectively. Although exposures did not exceed the OSHA Permissible Exposure Limit (PEL) of 5.0 mg/M^3, the slaker operator's exposure did exceed the ACGIH Threshold Limit Value (TLV) of 2.0 mg/M^3. Respirable dust samples collected from these same workers revealed particulate exposures of 0.5 and 1.2 mg/M^3 for the kiln operator and slaker operator, respectively. Since crystalline silica was not detected in the bulk samples of limestone and coke, further analysis of these respirable samples for crystalline silica was not indicated. These respirable dust levels are therefore comparable to the nuisance dust criteria of 5.0 mg/M^3.

Samples for CO obtained from lime kiln workers are presented in Table 6. Results show that measured CO levels were low, ranging up to 5 ppm. By comparison, the OSHA PEL for CO is 50 ppm and the NIOSH Recommended Exposure Limit (REL) is 35 ppm.

Air sampling results for coal dust, fly ash, and crystalline silica are presented in Table 7. Coal dust exposures ranged from 0.5 to 9.0 mg/M^3. The highest levels were measured from samples collected from the coal handler; both samples exceeded the ACGIH TLV and OSHA PEL of 2.0 and 2.4 mg/M^3, respectively. Pulp dryer and boiler coalmen were not exposed to coal dust at concentrations greater than 0.8 mg/M^3. Fly ash exposures ranged from 0.5 to 0.9 mg/M^3 (one sample was omitted since it contained excessive loose material); all were below the ACGIH TLV and OSHA PEL of 5.0 mg/M^3. Based on the fact that crystalline silica was present in the bulk samples of coal dust and fly ash, the personal air samples were analyzed for crystalline silica. Seven of the twelve personal air samples containing the highest dust loading were selected for crystalline silica analysis. Results indicated that one of these samples (obtained from the coal handler) contained 0.089 mg/M^3 crystalline silica which exceeded the NIOSH REL of 0.05 mg/M^3. The remaining four samples were not analyzed for crystalline silica since it was not detected in samples with similar dust loading.

Results of the personal air samples collected for respirable pulp dust are presented in Table 8. Pulp dust concentrations ranged from 0.2 to 1.4 mg/M^3 and were generally higher for the pellet mill operator than the pulp loader. (One sample, obtained from the pulp loader was omitted from this discussion because it contained excessive loose material). Because crystalline silica was detected in the settled rafter dust sample, the personal samples were analyzed for crystalline silica; but only those with sufficient dust loading. Of these 3 samples, two were analyzed and both were nondetectable (less than 0.015 mg/M^3). The remaining sample was not analyzed but would most likely have also been nondetectable since it contained less particulate material than the other two samples. Because the personal samples did not contain detectable quantities of quartz, the respirable dust concentrations are comparable to the ACGIH TLV and OSHA PEL of 5.0 mg/M^3 for nuisance dust.

Sugar dust air sampling results are presented in Table 9. Concentrations measured in the 12 personal samples ranged from 0.1 to 11 mg/M^3 and were generally highest for the Weibul housekeeping crew although several workers involved in housekeeping activities in the warehouse also had relatively high exposures. It should be noted that all of the Weibul housekeeping crew wore approved dust respirators, therefore, the reported values for these workers represent potential exposure. Two of the 12 personal samples exceeded the ACGIH TLV of 10 mg/M^3 while none exceeded the OSHA PEL of 15 mg/M^3.

Respirable gypsum and diatomaceous earth exposure results are presented in Table 10. The diffuser/filter operator's exposure to gypsum was measured at 1.1 and 1.2 mg/M^3 while the U.S. Filter operator's exposure to diatomaceous earth was measured at 0.7 and 0.2 mg/M^3. Since bulk samples of gypsum and Celite® did not contain detectable levels of quartz or cristobalite, the measured levels of these substances are comparable to the nuisance dust standard of 5.0 mg/M^3.

Table 11 presents the results of the general area air samples for formaldehyde, HCL, and BCME. Formaldehyde was detected in two of the four air samples, both collected from the diffuser. Levels were measured at 0.18 and 0.33 mg/M^3, and were higher at the bottom end of the diffuser where the formaldehyde was introduced. These levels, by comparison, were below the ACGIH TLV of 1.5 mg/M^3 and the OSHA PEL of 3.7 mg/M^3, as an 8-hour TWA. HCL was detected at low levels in three of the sites with levels ranging up to 0.07 mg/m^3; well below the environmental standard of 7 mg/M^3. BCME was not detected in any of the samples, even at the top end of the duffuser where both formadehyde and HCl were present.

Formaldehyde was detected in personal air samples obtained from the diffuser operator and watcher (Table 12). Two samples obtained from the diffuser operator revealed exposures of 0.25 and 0.37 mg/M^3. One sample collected from the diffuser watcher indicated an exposure of 0.11 mg/M^3. By comparison, these exposures were below the ACGIH TLV and OSHA PEL of 1.5

and 3.7 mg/M^3, respectively. NIOSH, however, recommends that exposures be reduced to the lowest feasible level since formaldehyde is a suspected human carcinogen.

B. Intercampaign (welding)

Air sampling results are presented in Table 13. Environmental concentrations are provided for total welding fumes and for those metals 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 13 along with those elements which were nondetectable.

Airborne concentrations of total welding fumes ranged from 0.9 to 19 mg/M^3. Thirteen (50%) of the samples exceeded the OSHA PEL of 5.0 mg/M^3. Specific metals or compounds which exceeded half of their respective most stringent exposure criteria include: total and hexavalent chromium (Cr VI), iron oxide, nickel, calcium oxide, and copper. Total chromium concentrations ranged from 0.1 to 1.2 mg/M^3. Three (11%) of the samples exceeded the ACGIH TLV of 0.5 mg/M^3 while one exceeded the OSHA PEL of 1.0 mg/M^3. Nine of eleven air samples analyzed for insoluble Cr VI could not be quantified because interferences (excessive levels of nickel, copper, iron and possibly other metals) were present in the samples. In the two samples where Cr VI was quantified, airborne concentrations were measured at 0.0004 and 0.0037 mg/M^3. The latter sample exceeded the NIOSH REL of 0.001 mg/M^3. Neither the OSHA PEL of 0.5 mg/M^3 nor the ACGIH TLV of 0.05 mg/M^3 for insoluble Cr VI were exceeded. Iron oxide concentrations ranged from 0.6 to 21 mg/M^3. Eight (30%) of the samples exceeded the OSHA PEL of 5.0 mg/M^3. Air sample values for nickel ranged from nondectable (ND) to 1.2 mg/M^3. Fourteen (54%) of the samples exceeded the NIOSH REL of 0.015 mg/M^3. One of the samples exceeded the OSHA PEL of 1.0 mg/M^3. Calcium oxide fume concentrations ranged from 0.1 to 2.6 mg/M^3. One sample exceeded the ACGIH TLV of 2.0 mg/M^3, while none exceeded the OSHA PEL of 5.0 mg/M^3. Copper fume levels ranged from ND to 0.11 mg/M^3. Three (11%) of the samples exceeded the OSHA PEL of 0.10 mg/M^3.

Compounds or elements which were detected but at levels below half of their respective most stringent occupational exposure limits included: aluminum oxide, barium, magnesium, manganese oxide, lead, and zinc oxide. All of these compounds/elements were below 5% of their respective most stringent occupational exposure limit, except for manganese which was below 45% of its most stringent criteria. All of the other compounds were nondetectable.

VII. Discussion and Conclusions

A. Campaign

The environmental sampling results show that workers were overexposed calcium oxide, coal dust, crystalline silica, sugar dust, and formaldehyde.

Observations of workers in the lime kiln area revealed that particulate exposures primarily resulted from sweeping/shoveling of dusts which had accumulated on the floors. The heaviest accumulations were observed below the calcium oxide conveyor system at the base of the lime kiln. An archaic open-track conveyor system is used to transport calcium oxide from the kiln to the slaker, and because of its inherent design there is ample opportunity for calcium oxide dust to fall through the tracks and onto the floor. Settled dust was also observed below the limerock and coke belt conveyors on the second level indicating that deficiencies existed with these systems as well.

Overexposures to coal dust and crystalline silica were documented for the coal handler. This job involved unloading of coal cars which frequently required that the worker get into the car to loosen frozen coal with a pick. Because we were unable to observe this operation to any extent it is unclear to what extent this task contributed significantly to the coal handler's overall exposure.

Airborne concentrations of sugar dust in excess of the ACGIH TLV for nuisance dust was measured in samples collected from the Weibul cleaning crew 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.

The air sampling results for formaldehyde indicate that this compound is released into the plant environment following its use in the diffuser. Although the airborne levels (0.11 to 0.37 mg/M^3) did not exceed the ACGIH TLV or OSHA PEL, they do represent a potential carcinogenic risk to exposed workers.

BCME was not detected in any of the four area air samples obtained from areas where formaldehyde and/or HCl were used. However, the potential for its formation appears to be greatest in the top end vicinity of the diffuser, since both HCl and formaldehyde were present in this area.

Although crystalline silica was not detected in air samples obtained from workers exposed to pulp dust, its presence in bulk samples suggest that sugar beet pulp dust is not inert but rather a substance that can potentially produce silicosis in exposed workers.

B. Intercampaign (welding)

The results of the environmental sampling indicate that workers engaged in welding and cutting operations were overexposed to various metals and/or to total welding fumes. Overexposures to nickel (54% of the samples collected) and insoluble Cr VI (at least 9% of the samples collected) are of particular concern since these two substances have been associated with the development of nasal and/or lung cancer in humans.

It must be emphasized that, because of the problems encountered in the Cr VI analysis, exposure to insoluble Cr VI may be greater than reported since this form of chrome was detected in most of the air samples NIOSH collected from workers welding/cutting on stainless steel at the East Grand Forks facility, where interferent metals were less of a problem.

The highest exposures to welding fumes were measured in samples obtained from workers welding inside the diffuser, a confined space work environment. Although portable local exhaust ventilation (LEV) systems were available to these workers, they were infrequently used during our evaluation. The infrequent use reportedly stemmed from the fact that the flexible ducting on these systems was not long enough to reach the bottom of the diffuser where most of the workers were welding. Furthermore, none of the diffuser welding crew wore respirators.

The remaining welders who worked in non-confined work settings throughout the plant used neither LEV nor respirators to protect themselves from generated contaminants.

The extent of the welding fume exposures (approximately two-thirds of the personal samples exceeded the most stringent occupational exposure criteria for 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 underlies the need for effective control measures to minimize worker exposures.

VIII. Recommendations

In view of the findings of the environmental evaluations the following recommendations (provided to the company and union via 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. 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, vacuum 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 settled rafter dust samples underlies the need for improvements to be made in the dust collection systems servicing the pulp/pellet conveyor systems. Reducing dust emissions from these conveyors should significantly reduce the housekeeping requirements in the pellet mill and exposures associated with cleaning activities.

3. Although dry sweeping may be more convenient, a 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, portable vacuum systems 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 exposure to formaldehyde to the lowest feasible level by implementation of engineering and/or administrative controls, with respiratory protection being used as an interim control measure.

5. The company should further evaluate the coal handler job to determine which tasks are hazardous in terms of coal dust exposure so that corrective actions can be taken. In the interim, appropriate respiratory protection should be worn.

6. The tote bag dumping system in the sugar bulk loading area should be better enclosed to minimize sugar dust emissions when sugar is dumped into the bag.

7. Flexible ducting on the portable welding fume exhausters used by the diffuser welding crew should be extended so that the exhausters can reach the bottom of the duffuser. This will enable workers to use these devices in all locations within the diffuser.

8. Portable local exhaust ventilation (LEV) systems should be used when welding or cutting in (other) confined spaces. In non-confined work areas, particularly when working with stainless steel, a primary source of carcinogenic hexavalent chromium, nickel, and other toxic metals, LEV systems should be used. When using LEV systems, the hood (typically the end of the duct) should be placed as close as practicable to the arc site. 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 of ventilation controls.

9. 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 at high concentrations.

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

11. 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.

12. 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.

13. 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).

14. Use of appropriate respiratory protection 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 requirements provided in 29 CFR 1910.134.

15. 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.

16. 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, Drayton Plant
2. American Crystal Sugar Company, Corporate Office
3. American Federation of Grain Millers, Minneapolis, Minnesota
4. American Federation of Grain Millers, Local 326
5. OSHA Region VIII

For the purpose of informing affected employees, copies of this report shall be posted by the employer in a prominent place accessible to the employees for a period of 30 calendar days.

Table 1

Potential Exposures During Campaign (Sugar Processing)

American Crystal Sugar Company
Drayton, North Dakota
HETA 85-044

January 30-31, 1985

Area	Job Classifications of Monitored Workers	Potential * Exposure(s)	Sources of Contaminants
Lime kiln	Lime kiln foremen, shaker operator	Coke, calcium carbonate Calcium oxide, crystalline silica, 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.
Diffuser, drum filter and knife station areas	Diffuser operator, diffuser watcher	Formaldehyde, hydrochloric acid, bischloromethyl ether	Formaldehyde is piped into inclined diffuser to control bacteria. Manual batch dumping of bagged paraformaldehyde into receptacle and open ports along length and top of diffuser are point sources of formaldehyde fugitive vapor emissions. Hydrochloric acid used to clear drum filters. BCME is not used at plant but may be formed from interaction of HCl and formaldehyde.[11]
Pulp pellet milk	Pellet mill operator and loaders	Beet pulp dust, crystalline silica	Pellet machines, pellet transfer equipment such as conveyors, front end loaders, housekeeping activities.
Boiler and pulp dryer areas	Coal and ash handlers	Coal dust, fly ash, crystalline silica	Unloading of coal from rail cars, maintenance and housekeeping activities.
Carbonation area	U.S. Filter operator, diffuser/filter operator	Diatomaceous earth gypsum	Manual bag charging of Celite® and gypsum into hoppers.
Weibuls, sugar bagging areas, bulk loading area, warehouse	Sugar baggers, housekeepings rail car loaders, warehouse cleaners	Sugar dust	Bulk loading of sugar into rail cars, sugar bagging, housekeeping activities.

Table 2

Sampling and Analysis Methodology

American Crystal Sugar Company
Drayton, North Dakota
HETA 85-044

Substance	Collection Device	Flowrate (Lpm)	Sampling Duration Range (hrs)	Analysis	Detection Limit (ug/sample)	NIOSH Reference Method[12,13]
			CAMPAIGN			
Bischloromethyl ether (BCME)	Impinger containing 15 mls 2,4,6-trichloro phenol	0.6	5.5 → 6.5	Gas chromatography	0.002	P&CAM 220
Calcium	AA filter	1.5	8.1 → 8.2	Atomic absorption	2	7020
Carbon monoxide	Draeger long-term indicator tube	0.020	6.8 → 8.2	Visual	-	-
Coal dust (respirable)	PVC filter with 10mm cyclone	2.0	7.2 → 8.2	Gravimetric	0.01	0600
Diatomaceous earth (respirable)	PVC filter	1.7	8.1 → 8.3	Gravimetric	0.01	0600
Fly ash (respirable)	PVC filter with 10mm cyclone	1.7	7.6 → 8.1	Gravimetric	0.01	0600
Formaldehyde	Solid sorbent tube	0.080	1.6 → 7.7	Gas chromatography	2	2502
Free silica (respirable)	PVC filter with 10mm cyclone	1.7	7.2 → 8.2	X-ray diffraction	15	7500
Gypsum (respirable)	PVC filter	1.7	7.7 → 8.1	Gravimetric	0.01	0600
Hydrochloric acid (HCl)	Solid sorbent tube	0.5	5.5 → 7.2	Ion chromatography	4	7903

(continued)

Table 2 (con'td)

Sampling and Analysis Methodology

American Crystal Sugar Company
Drayton, North Dakota
HETA 85-044

Substance	Collection Device	Flowrate (Lpm)	Sampling Duration Range (hrs)	Analysis	Detection Limit (ug/sample)	NIOSH Reference Method[12,13]
Pulp dust (respirable)	PVC filter with 10mm cyclone	1.7	7.9 → 8.3	Gravimetric	0.01	0600
Sugar dust	PVC filter	1.5	7.4 → 8.0	Gravimetric	0.01	0500
			INTERCAMPAIGN			
Chromium, hexavalent (insoluble)	FWSB filter	1.2	1.8 → 8.4	Visible spectroscopy	0.02	7600
Metals	FWSB filter	1.2	1.8 → 8.4	ICP-AES	See Appendix	7300
Welding Fume	PVC filter	1.0	1.8 → 8.4	Gravimetric	0.01	0500

Table 3

Environmental Criteria and Health Effects Summary

American Crystal Sugar Company
Drayton, North Dakota
HETA 85-044

Substance	Evaluation Criteria[1] (mg/M³) NIOSH REL	OSHA PEL	ACGIH TLV	Primary Health Effects	References
Bischloromethylether (BCME)	lowest feasible level	regulated carcinogen	0.005	Associated with an increased incidence of lung cancer in humans, highly carcinogenic in rodents.	2,3,4,5
Calcium oxide dust (total) Calcium oxide fume	-	5.0	2.0	Causes irritation of the eyes, mucous membranes, and skin. Dust inhalation may cause ulceration and perforation of nasal septum.	3,4,5
Carbon monxide	35 ppm	50 ppm	50 ppm	Combines with hemoglobin to form carboxyhemoglobin (COHb) which interferes with the oxygen carrying capacity of blood, resulting in tissue hypoxia. Formation of COHb is reversible. Symptoms include headache, drowsiness, nausea, and at high concentrations death can result.	2,3,4,5
Chromium	-	1.0	0.5	Severe upper respiratory irritant, nasal ulceration.	3,4,5,6
Chromium, hexavalent (insoluble)	0.001	0.5	0.05	Lung cancer, skin ulcers and lung irritation.	2,3,4,9
Coal dust (less 5% quartz)	-	2.4	2.0	Coal worker's pneumoconiosis.	3,4,5
Coal dust (greater than 5% quartz)	-	Crystalline silica formula			
Copper fume	-	0.1	0.2	Irritation of the upper respiratory tract, metal fume fever.	3,4,6
Crystalline silica (respirable)[2]	0.05	$\frac{10\ mg/M^3}{\%\ SiO_2+2}$	$\frac{10\ mg/M^3}{\%\ SiO_2+2}$	Silicosis; a pneumoniosis due to the inhalation of silicon dioxide-containing dust, which is a disabling, progressive, and sometimes fatal pulmonary fibrosis characterized by the presence of typical nodulation in the lungs.	2,3,4,5
Diatomaceous earth (respirable)[2]	-	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.	3,4,6

continued

Table 3 (con'td)

Environmental Criteria and Health Effects Summary

American Crystal Sugar Company
Drayton, North, Dakota

Substance	Evaluation Criteria[1] (mg/M^3) NIOSH REL	OSHA PEL	ACGIH *TLV	Primary Health Effects	References
Fly ash[2]	-	5.0	5.0	Same as above.	3,4,6
Formaldehyde	lowest feasible level	3.7 (3.0ppm)	1.2(c) (1.0 ppm)	Vapors can cause irritation of the eyes and upper respiratory tract. Animal carcinogen. Contact with liquid can cause both primary irritation and sensitization dermatitis.	2,3,4,8
Gypsum (respirable)[2]	-	5.0	5.0	Regulated as a nuisance particulate. Refer to health effects described for diatomaceous earth.	3,4,6
Hydrochloric acid (HCl)	7.0	7.0	7.0(c)	A strong irritant of the eyes, mucous membranes, and skin.	2,3,4,14
Iron oxide	-	5.0	5.0 (10.0 STEL)	Siderosis-a benign pneumoconious or respiratory condition associated with inhalation of particles.	3,4,5
Nickel, inorganic (as Ni)[3]	0.015	1.0	1.0	Respiratory iritation from fume, skin effects; lung and nasal cancer.	2,3,4,10
Sugar beet pulp dust (respirable)[2]	-	5.0	5.0	Regulated as a nuisance particulate. Refer to health effects described for diatomaceous earth.	3,4,6
Sugar dust (total)	-	15.0	10.0	Same as above.	3,4,6
Welding fumes (N.O.C)	-	5.0	5.0	Toxicity of component metal must be considered individually.	3,4,6

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% 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.

N.O.C.= Not otherwise classified.

(c) Ceiling limit; exposures shall not exceed this concentration.

(STEL) = Short-term exposure limit, considered a maximum allowable concentration, not to be exceeded at any time during the 15 minute excursion period.

Table 4

Crystalline Silica Content in Bulk and Settled Rafter Dust Samples

American Crystal Sugar Company
Drayton, North Dakota
HETA 85-044

January 30-31, 1985

Substance	Crystalline Silica (% by wt.) Quartz	Cristobalite
Beet pulp dust	1.9	<0.75
Coal dust	1.0	<0.75
Fly ash	7.8	<0.75
Limestone	<0.75	<0.75
Coke	<0.75	<0.75
Celite® (diatomaceous earth)	<0.75	<5.0*
Gypsum	<0.75	<0.75
Laboratory Limit of Detection (% by wt.):	0.75	0.75

* Interference was present in sample which consequently decreased the sensitivity of the analysis, resulting in a LOD of 5.0% by weight.

Table 5

Calcium Oxide and Respirable Particulate Exposures of Workers
Associated with the Lime Kiln

American Crystal Sugar Company
Drayton, North Dakota
HETA 85-044

January 30-31, 1985

Date	Sample Description	Sample Duration	Sample Volume (L)	Airborne Concentration (mg/m^3) Calcium Oxide	Respirable Particulate
1-30-85	Lime kiln foreman	0745-1558	838	-	228*
1-31-85	Lime kiln foreman	0748-1558	833	-	0.5
1-31-85	Lime kiln foreman	0748-1558	735	1.5	-
1-30-85	Slaker operator	0749-1602	838	-	1.2
1-31-84	Slaker operator	0750-1555	728	2.1	-
Environmental criteria:		NIOSH REL		-	-
		ACGIH TLV		2.0	5.0
		OSHA PEL		5.0	5.0

* Sample invalid due to excessive loose material in filter cassette.

Table 6

Personal and Manual Area Carbon Monoxide Concentrations

American Crystal Sugar Company
Drayton, North Dakota
HETA 85-044

January 30-31, 1985

Date	Sample Description	Sampling Duration	CO Concentration (ppm)
1-30-85	Lime kiln foreman	0745-1558	2
1-30-85	Lime kiln limestone/coke man	0749-1602	ND
1-31-85	Lime kiln limestone/coke man	0750-1555	5
1-30-85	Area sample, gas turbine	0949-1540	4
1-30-85	Area sample, above trap for lime kiln gas	0952-1540	5
Environmental criteria:	OSHA PEL		50
	NIOSH REL		35

ND = nondetectable, less than 1 ppm

Table 7

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

American Crystal Sugar Comapny
Drayton, North Dakota
HETA 85-044

January 30-31, 1985

Date	Sample Description	Sampling Duration	Sample Volume (L)	Airborne Concentration (mg/m^3) Coal Dust	Fly Ash	Quartz
1-30-85	Boiler coalman	0804-1532	896	0.5	-	NA
1-31-85	Boiler coalman	0755-1537	924	0.5	-	NA
1-30-85	Boiler ashman	0730-1534	823	-	0.5	NA
1-31-85	Boiler ashman	0758-1535	777	-	0.5	NA
1-30-85	Boiler helper	0800-1535	773	-	0.8	ND
1-31-85	Boiler helper	0800-1556	809	-	0.8	ND
1-30-85	Coal handler	0820-1532	864	6.9	-	ND
1-31-85	Coal handler	0810-1537	894	9.0	-	0.089
1-30-85	Pulp dryer coalman	728-1542	988	0.8	-	ND
1-31-85	Pulp dryer coalman	0741-1551	980	0.6	-	ND
1-30-85	Pulp dryer ashman	0801-1544	787	-	0.9	ND
1-31-85	Pulp dryer ashman	0757-1557	816	-	29*	-
Environmental criteria:		NIOSH REL		-	-	0.050
		ACGIH TLV		2.0	5.0	0.100
		OSHA PEL		2.4	5.0	10 / % quartz +2

* Sample invalid due to excessive loose material in filter cassette.
ND = Not detected; less than 0.015 mg/m^3.
NA = Not analyzed; quartz in these samples would have been nondetectable since the other samples of similar particulate loading were nondetectable.

Table 8

Personal Samples for Respirable Pulp Dust and Crystalline Silica

American Crystal Sugar Company
Drayton, North Dakota
HETA 85-044

January 30-31, 1985

Date	Sample Description	Sample Duration	Sample Volume (L)	Airborne Concentration (mg/m^3)	
				Pulp Dust	Quartz
1-30-85	Pellet mill operator	0752-1600	830	1.4	ND
1-31-85	Pellet mill operator	0752-1545	804	0.3	ND
1-30-85	Pulp loader	0732-1553	852	45*	-
1-31-85	Pulp loader	0748-1545	811	0.2	NA
Environmental criteria:			NIOSH REL	-	0.050
			ACGIH TLV	5.0**	0.100
			OSHA PEL	5.0**	

* Sample invalid due to excessive loose material in filter cassette.
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 similar particulate loading were nondetectable.
** Although crystalline silica was not present in the personal air samples its presence in the bulk sample suggests that pulp dust is not biologically inert but rather a substance that can potentially produce silicosis in exposed workers.

Table 9

Personal Sugar Dust Exposures

American Crystal Sugar Company
Drayton, North Dakota
HETA 85-044

January 30-31, 1985

Date	Sample Description	Sample Duration	Sample Volume (L)	Sugar Dust Airborne Concentration (mg/m^3)
1-30-85	Sugar bagger	0832-1555	664	0.1
1-30-85	Weibul housekeeper	0808-1542	681	11
1-30-85	Weibul housekeeper	0805-1543	687	11
1-31-85	Weibul housekeeper	0800-1550	705	8.7
1-31-85	Weibul housekeeper	0804-1547	694	7.1
1-30-85	RR car loader	0755-1537	693	2.9
1-30-85	RR car loader	0756-1543	700	3.2
1-31-85	Warehouse sweeper	0814-1550	684	3.2
1-31-85	Warehouse sweeper	0752-1530	687	1.8
1-30-85	Warehouse sweeper	0754-1555	721	5.0
1-31-85	Forklift operator/clean-up	0759-1530	676	1.9
1-31-85	Palletizer operator/clean-up	0753-1555	723	9.7
Environmental criteria:		ACGIH TLV		10
		OSHA PEL		15

Note: The Weibul housekeeping crew wore approved dust respirators therefore the reported values for these workers represent potential exposures.

Table 10

Respirable Gypsum and Diatomaceous Earth Exposures of Filter Operators

American Crystal Sugar Company
Drayton, North Dakota
HETA 85-044

January 30-31, 1985

Date	Sample Description	Sample Duration	Sample Volume (L)	Airborne Concentration (mg/m³) Diatomaceous Earth* (Celite®)	Gypsum
1-30-85	U.S. Filter operator	0759-1558	849	0.7	-
1-31-85	U.S. Filter operator	0756-1600	823	0.2	-
1-30-85	Diffuser & filter operator	0817-1602	790	-	1.1
1-31-85	Diffuser & filter operator	0753-1600	828	-	1.2
Evaluation criteria:		NIOSH REL		-	-
		OSHA PEL		5.0	5.0
		ACGIH TLV		5.0	5.0

* Celite® is generically classified as diatomaceous earth.

Table 11

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

American Crystal Sugar Company
Drayton, North Dakota
HETA 85-044

January 30, 1985

Location	Sample Duration		Airborne Concentration (mg/m^3) Formaldehyde*	HCL	BCME**
Diffuser, top end	0906-1540		0.18	0.04	ND
Diffuser, bottom end	0920-1530		0.33	ND	ND
Drum filter #2, on catwalk above	0930-1540		ND	0.07	ND
Knife station	0912-1540		ND	0.06	ND
Environmental criteria:		NIOSH REL	Lowest level feasible	7	Lowest level feasible
		OSHA PEL	3.7	7	Regulated carcinogen
		ACGIH TLV	1.5	7(c)	0.0047

* NIOSH and ACGIH consider formaldehyde a potential human carcinogen.
**NIOSH, OSHA, ACGIH regard BCME a confirmed human carcinogen.
(c) = ceiling limit
ND = not detected; less than 2 micrograms (ugs) per sample for formaldehyde; 4 ugs per sample for HCl; and 0.002 ugs per milliliter for BCME.

Table 12

Personal Samples for Formaldehyde

American Crystal Sugar Company
Drayton, North Dakota
HETA 85-044

January 30-31, 1985

Date	Sample Description	Sample Duration	Sample Volume (L)	Formaldehyde* Concentration (mg/m3)	(ppm)
1-30-85	Diffuser operator	0817-1602	37	0.25	0.21
1-31-85	Diffuser operator	0231-1600	13.5	0.37	0.31
1-31-85	Diffuser watcher	0801-1525	35	0.11	0.09
Environmental criteria:		NIOSH REL		Lowest level feasible	
		ACGIH TLV		1.5	1.0
		OSHA PEL		3.7	3.0

NIOSH and ACGIH consider formaldehyde a potential human carcinogen.

Table 13

Personal Air Sampling Results for Welding Fumes

American Crystal Sugar Company
Drayton, North Dakota
HETA 85-044

June 6-7, 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	Copper
6-6-85	Inside diffuser	Repairing flights	0703-1516*	387	15		**				
		and walls		464		0.6		13	0.690	0.3	0.10
6-6-85	"	"	0821-1545	444	11		**				
				533		0.7		12	0.730	0.2	0.10
6-7-85	"	"	0750-1547	477	19		**				
				572		1.2		21	1.206	0.4	0.11
6-6-85	"	"	0824-1545	441	5.3		**				
				529		0.2		5.9	0.210	0.3	0.05
6-7-85	"	"	0750-1454*	400	3.9		0.0037				
				480		0.1		1.8	0.046	0.3	ND
6-6-85	"	"	0818-1541*	446	4.0		**				
				535		0.2		3.3	0.205	0.2	0.02
6-7-85	"	"	0751-1507*	439	11		**				
				527		0.1		3.9	0.068	0.7	trace
6-6-85	"	"	0816-1542*	449	3.6		0.0004				
				539		trace		1.0	0.009	0.3	ND
6-7-85	"	"	0749-1545*	259	5.9		**				
				311		0.1		3.5	0.093	0.4	trace
6-6-85	"	"	0817-1545*	423	5.3		**				
				508		trace		4.0	0.022	0.3	0.01
6-7-85	"	"	0752-1532*	454	7.7		**				
				545		0.1		3.5	0.079	0.6	trace
6-6-85	Pulp press deck	Deck extension	0822-1605*	463	2.0		NA				
	area			556		trace		0.9	0.007	0.1	trace
6-7-85	"	"	0801-1651*	452	3.1		NA				
				542		trace		2.9	0.004	0.1	trace
6-6-85	"	"	0814-1620*	384	2.5		NA				
				461		0.1		2.4	0.048	0.3	0.02
6-7-85	"	"	0802-1616*	378	4.3		NA				
				454		trace		1.5	0.007	0.2	ND
6-6-85	Lime kiln	Replacing limerock	0807-1619*	496	4.6		NA				
	4th floor	chute		595		trace		1.9	0.012	1.0	trace
6-6-85	"	"	0800-1613	493	5.5		NA				
				592		trace		4.2	0.009	2.6	trace
6-6-85	Wet hopper	Replacing flume	0812-1557	465	13		NA				
	(outdoors)	walls		557		trace		7.2	0.008	1.0	0.01
6-7-85	"	"	0800-1613*	487	2.5		NA				
				584		trace		1.3	0.003	0.4	ND

(continued)

Table 13 (con'td)

Personal Air Sampling Results for Welding Fumes

American Crystal Sugar Company
Drayton, North Dakota
HETA 85-044

June 6-7, 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	Copper
6-6-85	Knife station Area	Installing catwalk	0811-1620*	372	6.6		NA				
				446		trace		6.0	0.043	0.8	ND
6-7-85	"	"	0805-0953	108	9.5		NA				
				130		trace		11	0.020	0.4	ND
6-6-85	Beet washer room	Building-up disintegrator hammers	0808-1630	502	3.9		NA				
				602		0.1		2.7	0.023	0.2	trace
6-7-85	"	"	0820-1453	393	1.1		NA				
				472		trace		2.1	0.012	0.4	ND
6-6-85	Below centrifugals	Replacing bottoms of seal pot	0810-1620	490	0.9		NA				
				588		trace		0.6	ND	0.1	ND
6-7-85	"	"	0805-1608*	327	15		NA				
				392		trace		7.3	0.003	0.3	0.02
6-6-85	Pan floor	Installing spray line to #1 evaporator	0804-1242	278	2.3		NA				
				334		trace		0.9	ND	0.4	trace
Environmental criteria:				NIOSH REL	-	-	0.001	-	0.015	-	-
				OSHA PEL	5.0	1.0	0.5	5.0	1.000	5.0	0.1
				ACGIH TLV	5.0	0.5	0.05	5.0	1.000	2.0	0.2

* 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 precluded quantitation of hexavalent chromium.

Trace = Less than 0.05 mg/M^3 for total chromium; less than 0.005 for copper.

ND = Not detected, less than 0.001 mg per sample, for nickel and copper.
NA = Not analyzed because no welding was done on stainless steel, a source of hexavalent chromium.

NOTE: Other elements or compounds which were detected in these air samples included: aluminum oxide, barium, magnesium, manganese oxide, lead, and zinc oxide. All of these were below 5% of their respective most stringent environmental exposure limits, except for manganese oxide which was less that 45% of its exposure limit.

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

Appendix

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

American Crystal Sugar Company
Drayton, North Dakota
HETA 85-044

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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