U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
CENTER FOR DISEASE CONTROL
NATIONAL INSTITUTE FOR OCCUPATIONAL SAFETY AND HEALTH
CINCINNATI, OHIO 45226

HEALTH HAZARD EVALUATION DETERMINATION
REPORT NO. 79-48-626

LEVER BROTHERS COMPANY
PAGEDALE, MISSOURI 63133

OCTOBER, 1979

I. TOXICITY DETERMINATION

A health hazard evaluation was conducted by the National Institute for Occupational Safety and Health (NIOSH) from April 9 through April 12, 1979, at Lever Brothers Company, Pagedale, Missouri, to evaluate workers' complaints of dermatitis, dizziness, and soreness of mucous membranes during detergent manufacturing operations. The evaluation methodology consisted of (a) medical interviews of 30 employees and a limited physical examination of 28 employees; (b) environmental sampling of known air contaminants; (c) laboratory determinations of contaminants; (d) literature review of known chemicals and their physiological effects; and (e) inspection of the workplace and personal observations.

The following is a summary of conclusions:

A. A large number of employees (70 to 75 percent) evidenced mucous membrane irritation of the eyes, nose, and throat with irritation of the eyes being most prevalent. One third of the participants examined were affected by skin irritation and/or rash. Other common complaints include respiratory symptoms and excessive fatigue while on the job. These symptoms were mostly mild in nature, but appeared to be more prevalent during the processing of "carbonate" products.

B. Personal air sample results for the general worker number 1 and the general relief worker of the South Tower were 31.7 mg/M^3 (milligrams of substance per cubic meter of air) and 22.5 mg/M^3, respectively, for total nuisance particulates. These results exceeded the environmental criteria of 10 mg/M^3 for total nuisance particulates. All other personal air sample results were below the criteria for total nuisance particulates. Boron was not detected in any of the personal air samples, and thus, did not present a hazard at the time of the survey.

C. Three out of six bulk samples from the insulation of the North and South Towers were positive for asbestos with a maximum of 20-30 percent asbestos as amosite only. There were no operations (e.g., replacing or adding insulation, etc.) being conducted at the time of the survey which would generate airborne asbestos; hence, no air samples were obtained for asbestos.

D. Eight bulk samples of products used in the process (e.g., final product, dicalite, or perlite, borax, etc.) were obtained and analyzed for beryllium, arsenic, and "free" silica as quartz and cristobalite. These compounds were not detected in the bulk samples and are not mentioned further in the report.

E. Although characterization of the health hazards present in an alkaline environment is difficult because of the limitations of air sampling, analytical methodology, and the possible effects of alkaline or other materials on the skin and mucous membranes, we conclude that the overall environmental conditions are potentially toxic to employees in the North and South Towers.

Detailed information concerning the above items plus pertinent observations concerning work practices and other items are contained in the body of this report. Recommendations are included in this report which are designed to minimize employee exposure.

II. DETERMINATION AND AVAILABILITY OF DETERMINATION REPORT

Copies of this Determination Report are currently available upon request from NIOSH, Division of Technical Services, Information Resources and Dissemination Section, 4676 Columbia Parkway, Cincinnati, Ohio 45226. After 90 days, the report will be available through the National Technical Information Service (NTIS), Springfield, Virginia. Information regarding its availability through NTIS can be obtained from NIOSH Publication Office at the Cincinnati address.

Copies of this report have been sent to:

a) Lever Brothers Company
b) Authorized Representative of the International Chemical Workers - Local Union 344.
c) U.S. Department of Labor - Region VII
d) NIOSH - Region VII

For the purpose of informing the approximately 28 "affected employees", the employer shall promptly "post" for a period of 30 calendar days, this Determination Report in a prominent place(s) near where exposed employees work.

III. INTRODUCTION

Section 20(a)(6) of the Occupational Safety and Health Act of 1970, 29 U.S.C. 669(a)(6), authorizes the Secretary of Health, Education, and Welfare, following a written request by an 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 National Institute for Occupational Safety and Health received such a request from an authorized representative of the International Chemical Workers Local Union No. 344 concerning employees' complaints of dermatitis, dizziness, soreness of mucous membranes, and drowsiness during processing operations in the North and South Tower facilities at the Lever Brothers Company, Pagedale, Missouri.

IV. HEALTH HAZARD EVALUATION

A. Description of Process

The Lever Brothers Company at Pagedale, Missouri, has in excess of 600 hourly production, administrative, and engineering employees who are involved in the manufacturing of various types of detergents and similar products. This request specifically involved the manufacturing of "carbonate" (sodium carbonate) powder detergents. These operations involve approximately 20 production employees and 8 ancillary and supervisory employees in the finishing or production departments. It does not include the packaging departments which package the final product prior to shipment. There are two similar production areas or lines. Each processes several tons of detergent per hour of operation.

The two production areas consist of several large storage tanks for the main raw and final materials used in the process. The majority of these materials are transferred to crutcher tanks for mixing into a slurry. The slurry is pumped to the top of a large heated tower where the slurry is sprayed into the tower via several nozzles. The detergent droplets flow down the silo for several stories through forced heated air (e.g., several hundred degrees Fahrenheit). The solid detergent droplets are collected at the bottom of the silo. The solid particulates are processed through a scalping screen, and fluidizer, additional minor amounts of other ingredients (e.g., colorants, perfume, etc.), followed by final screening, and packaging operations end the process. Materials are transferred from one bin or vat to another via pumps, bucket elevators, pneumatic tubes, conveyor belts, and similar devices.

The two production lines or areas are referred to as the North Tower and the South Tower. Most of the ancillary equipment (e.g., storage and mixing tanks, etc.) are located on the 3rd, 4th, and 5th floors. The South Tower or silo started production in 1953, and the North Tower started production in 1971. Both towers were processing "carbonate" products at the time of the survey.

The major ingredients used in the formulation of the products processed at the time of the survey were sodium carbonate, sodium sulfate, sodium silicate, linear long-chained alcohols treated with ethylene oxide, and alkylbenzene sulfonic acids. Minor additives may include sodium tetraborate or other boron compounds, colorants and/or dyes, perlite and perfume.

B. Evaluation Progress and Methods

1. Progress

An initial NIOSH walk-through as well as an environmental-medical survey of processing operations in the North and South Towers were conducted from April 9 through April 12, 1979, by three industrial hygienists and one physician's assistant. An exit interview was held with appropriate representatives of union and management to discuss any preliminary observations and findings, and to answer any questions concerning this evaluation and subsequent reports. An interim summary report of observations, preliminary findings, and recommendations was sent to management and union representatives on May 1, 1979. It was necessary to evaluate the analytical results of the bulk samples before making a decision on what compounds to analyze for in the air samples. This delay more than doubled the normal time allotted for analysis of the air samples.

2. Environmental Design and Methods

Bulk samples of several chemicals used in the formulation of the detergent products being processed at the time of the survey were obtained and submitted to NIOSH laboratories in Cincinnati and Salt Lake City for analysis of possible contaminants which may produce some adverse symtomatology. The manufacturers of the various products used in formulating the two products have been contacted to ascertain the specific chemicals and the effect they may produce in humans. In addition, a total of six bulk samples of insulation on the North and South Towers were obtained and submitted for analysis of asbestos.

Two bulk samples of the finished products and two bulk samples of a mixture of most of the major ingredients (do not contain perfume, dacilite, etc.) from both towers were obtained and analyzed for percent sodium (Na^+), percent hydroxide ion (OH^-), percent carbonate ion ($CO_3^=$), and percent bicarbonate ion (HCO_3^-). In addition, bulk samples of the finished products from each tower were separately ground and mixed. Then for each sample, two 50 milligram (mg) portions were weighed onto AA filters in cassette holders. Through one filter, a total of one cubic meter of air was passed at a rate of two liters per minute. This resulted in two samples (one sample with air passed through it and one sample with no air passing through) of the finished product (one from each tower) for a total of four samples. The reason for passing air through the sample was to ascertain if there was any change in the bulk materials due to the carbon dioxide and water vapor concentrations in air.

It is noted that passing of air through the samples did not produce any noticeable change in the bulk materials from either tower. The above samples were prepared and analyzed according to an alkalinity method for water as found in Standard Methods for Examination of Water and Waste Water, 1975, pp 278. The method is based on the assumption that the

alkalinity is due mainly to sodium hydroxide, sodium carbonate, and sodium bicarbonate. The average sodium hydroxide concentration of the above bulk samples was less than 1 percent and hence, not discussed further in this report as it is not considered a hazard at the time of the survey. The samples were also analyzed for sodium using atomic absorption methods contained in NIOSH Manual of Analytical Methods, HEW Publication No. (NIOSH) 77-157, Cincinnati, Ohio - 1977. All of the analytical results for the bulk samples were very close with the average of these results as follows:

a. North Tower bulk samples contained an average concentration of 20 percent Na^+, 6.225 percent HCO_3^-, and 21.55 percent $CO_3^=$.

b. South Tower bulk samples contained an average concentration of 19.5 percent Na^+, 6.6 percent HCO_3^-, and 19.425 percent $CO_3^=$.

The analytical method applied to these samples is subject to interferences from some compounds such as borates and silicates. The extent of such interferences is not known. Because of reaction between the hydroxide and bicarbonate ion, they do not co-exist in solution. Nevertheless, the alkalinity measurements on these samples are based on pH changes similar to those produced by hydroxide (less than 1 percent), carbonate, and bicarbonate regardless of what the actual sources of these pH changes might be. The matter of interferences in the above samples is almost a moot question, since the results indicate that the alkalinity is mainly from sodium carbonate.

Air samples via personal and area sampling apparatuses were used to assess the potential exposure of 19 production employees to various contaminants. DM 800 vinyl chloride acrylonitrile filters in two or three piece cassettes were obtained using an MSA pump at a sampling rate of 1.5 liters per minute (lpm). FWSB polyvinyl chloride filter samples in a two piece cassette were obtained for total dust and respirable dust (e.g., 10 mm cyclone for repirable dust) using an MSA pump at a sampling rate of 1.7 lpm. Originally, the DM 800 filters were obtained for total nuisance particulates, sodium, and boron; and the FWSB filters for total or respirable particulates and "free" silica. However, as the bulk samples showed no "free" silica, and hence all of the air samples were analyzed for total respirable particulates, sodium and boron. All of the DM 800 and FWSB filter samples were analyzed via gravimetric and atomic emission spectrophotometry methods for nuisance particulates, boron, and sodium contained in the above referenced NIOSH Manual of Analytical Techniques.

Six bulk samples of the insulation materials used in the North and South Towers were obtained and analyzed for asbestos. A visual estimation of the percentage of asbestos was made on the samples utilizing phase contrast, polarizing, and dispersion techniques contained in the NIOSH Manual of Analytical Techniques and the NIOSH Applications Manual.

It is difficult to characterize an alkaline environment without being specific as to what is the primary concern. For instance, analysis of the bulk samples of materials processed showed that a 0.75 percent solution of the bulk with water results in a pH of 11.0 (pH of 7 is considered neutral) which is a fairly strong alkaline solution. Further evaluations

of the solutions of the bulk samples show that there is little or no sodium hydroxide detected as expected due to reaction of hydroxide with the bicarbonate in the mixture. The main concern is the carbonate concentration with the bicarbonate concentration of secondary concern. It is an inordinate amount of work to analyze all of the filter samples for carbonate and bicarbonate concentrations, and the results may be of questionable nature due to the small amounts of particulates on the filter. Hence, the amount of sodium carbonate and sodium bicarbonate concentrations were calculated based on the information obtained from the analysis of the bulk samples presented above and the analysis of the filter samples for total sodium. An example of how the calculations for sodium carbonate and sodium bicarbonate are accomplished is presented in appendix A of this report. At least 90 percent of the total sodium is accounted for by the sodium carbonate and sodium bicarbonate concentrations with 10 percent of the sodium coming from sources such as sodium silicate and other compounds. This method appears to be a reasonable approach for purposes of this report.

3. Medical Design and Methods

A total of 30 production workers participated in the medical aspect of this health hazard evaluation. Each of these workers was either currently working in the dry powder production areas (North/South Tower Complex), or had worked extensively in the tower area in the past. Each person was queried via a standard non-directed questionnaire. A physical exam with particular emphasis on the respiratory system, the skin, and mucous membranes (eyes, nose, and throat) was given each worker (save two individuals who were questioned via the phone). In addition to the questionnaire and physical exam, a general review was made of the individual worker's company generated medical records.

C. Evaluation Criteria

1. Environmental Criteria

The three primary sources of environmental evaluation criteria considered in this report are: (a) NIOSH Criteria Documents with recommended standards for occupational exposure; (b) American Conference of Governmental Industrial Hygienists (ACGIH) Threshold Limit Values (TLV's) with supporting documentation; and (c) Federal Occupational Health Standards as promulgated by the Occupational Safety and Health Administration, U.S. Department of Labor (29 CFR 1910.1000). For the substances evaluated during this study, the primary environmental criteria considered most appropriate are:

TABLE OF ENVIRONMENTAL CRITERIA

SUBSTANCE	STANDARD OR GUIDE mg/M^3*
Total Nuisance Particulates (Dusts)	10.0(b)
Respirable Nuisance Particulates (Dusts)	5.0(b)
Sodium tetraborate, pentahydrate	1.0(b)

*Approximate milligrams (mg) of substance per cubic meter (M^3) of air sampled.

Occupational health exposure limits for individual substances are generally established at levels designed to protect workers occupationally exposed on an 8 hour per day, 40 hour per week basis over a normal working lifetime.

There are no established environmental standards or criteria for sodium carbonate or sodium bicarbonate. Detergent dusts or particulates should not be considered as nuisance dusts as they are active from a chemical and biological standpoint. Hence, the criteria above for nuisance dusts should not be used for detergent particulates or dusts as the levels should be more restrictive for these dusts. The NIOSH recommended environmental criteria for sodium hydroxide is 2.0 mg/M^3. Sodium hydroxide is considered a strong alkaline compound and sodium carbonate as a less alkaline compound. Hence, the criteria for sodium hydroxide is not considered as appropriate for sodium carbonate. For purposes of this report, an arbitrary level of 1 mg/M^3 or more for particulate dust samples was selected to calculate sodium carbonate and sodium bicarbonate concentrations of the filter samples. An arbitrary level was established as there was little correlation between air concentrations and the medical results found in this study. However, levels at or above 1 mg/M^3 of detergent particulates or dusts may be useful as a screening limit for those samples which may be significant and need further attention and evaluation by the investigators. The authors feel that there is insufficient information from this study or other studies to establish any criteria or standard for sodium carbonate and sodium bicarbonate. Also, the establishment of an airborne standard primarily considers uptake by the respiratory tract with irritation of the mucous membrances, and normally does not include the effect and uptake by the skin and gastrointestinal tract. Reference 1 of this report presents an excellent summary or critique concerning sodium hydroxide, sodium carbonate and sodium bicarbonate.

2. Biological Criteria - Review of Literature - References 1-14

Biological criteria are based on the observable health effects of exposure to the work environment usually in reference to a biologically normal condition. Exposures include not only the breathing concentrations, but also, direct skin contact with solvents, cleaning agents, and other chemicals. Effects and/or absorption via the skin of various chemicals as well as absorption via the gastrointestinal tract from hands contaminated with various chemicals are major areas of concern, but areas where there is only limited information which is not normally considered when establishing airborne standards or criteria. General information on the major compounds considered in this evaluation are discussed below.

Nuisance Dusts or Particulates--Nuisance dusts have few adverse effects on the lungs and do not produce significant disease or toxicity when exposures are kept under reasonable control. These dusts are composed so that when inhaled, the architecture of the alveoli remains in tact, little or no scar tissue is formed, and any reaction provoked is potentially reversible. Excessive concentrations in workroom air may reduce visibility, cause unpleasant accumulations in the eyes, ears, and nose, and secondarily cause injury to the skin due to vigorous cleansing procedures necessary for their removal.

Dicalite or Perlite--Dicalite is a trademark for a group of products made from either diatomite or perlite which has diatomaceous earth as its major ingredient. Perlite is considered as relatively biologically inert so that when inhaled, it reacts similarly to nuisance dusts. In fact, the ACGIH recommended environmental criteria for perlite is 10 mg/M^3 for total dust and 5 mg/M^3 for respirable dusts is the same as nuisance dusts. When soda ash is added to crushed diatomaceous earth, the resulting powder, when heated at high temperatures, is known as fluxcalcined. High temperatures and the addition of soda ash convert varying amounts of the amorphous noncrystalline powder to crystalline forms of silica well known to be fibrogenic (capable of causing a thickening of lung tissue). However, analysis of materials used as well as the finished products did not indicate any "free" or crystalline forms of silica. Hence, it would be appropriate to use the criteria of 10 mg/M^3 for total particulates and 5 mg/M^3 for respirable particulates of perlite.

Sodium Carbonate--(Soda ash) (Na_2CO_3)--The pH of a 1 percent solution of Na_2CO_3 in water is about 11.5. Na_2CO_3 is a primary skin irritant, causing dermatitis by direct action on the skin at the site of contact. The free caustic dust may cause irritation of the eyes, respiratory tract, and erosion of the nasal septum. The greatest hazard is that of destruction of any tissue upon contact with the solid or concentrated solutions, and particularily a splash or dust particles entering the eyes of workers. This can be prevented by the use of eye protection that is affective at all angles and also, the use of protective clothing covering skin areas.

Borates, Tetra, Sodium Salts, (e.g., Pentahydrate, etc.)--Sodium tetraborate pentahydrate and similar compounds have an occupationally important property which is their accute irritant effect when in contact skin and mucous membranes of the eyes, nose, and other sites in the respiratory tract. The irritant property increases with decreasing water of hydration due to the exothermic effect of hydration. Previous studies[4,5,9,11] and current data are not adequate to establish the existence of a causal relationship between inhalation exposure to sodium tetraborates and chronic respiratory and/or systemic effects. Drowsiness, fatique, and headache have also been attributed to exposure of workers to these compounds. However, it is believed that the 1.0 mg/M^3 limit for pentahydrate compounds will prevent the acute irritant effects. These compounds may enter the

body by inhalation, ingestion, or by absorption through the mucous membranes. Limited absorption occurs through undamaged skin. Absorption through damaged skin is more rapid and almost complete. Following absorption, there is a rise in boron in the cerebrospinal fluid and in the brain and other organ tissues such as liver. Repeated exposures have a cumulative effect with retention being greatest in the bone tissue. The authors feel that additional attention should be given to the toxicology of these compounds with better studies and literature reviews.

Linear Alkylbenzine Sulfonates (LAS)--The large scale conversion of the detergent industry to the production of LAS in which the alkyl radical consists of linear, straight chain moiety is expected to greatly reduce residue levels of detergent compounds in the environment. This is so because these linear chains are rapidly degraded by micro-organisms in soil and sewage sludges. The previous used branch-chain alkyl benzene sulfonates (ABS) were slow degraders. Rat toxicologic[21] studies detailed no abnormal variations in target organs, with the possible exception of a slight increase in liver weight. LAS is a strong skin irritant and has been implicated as a cause of contact dermititis. Protective clothing and thorough washing of exposed skin areas will help prevent skin irritation.

The above is a summary of some of the major biological criteria which were considered in this evaluation and represent some of the considerations involved. However, there are several other compounds (e.g, perfume, etc.) used in the formulation of detergent products which are not discussed above because of their low toxicity potential or due to the "business confidential" nature of the compound(s) such as perfume. Hence, the authors decided that based upon the above information, analysis of the bulk samples and other considerations from previous studies, the emphasis of this study shall be confined to those considerations contained in section IV D1-"Environmental Results and Discussion" and IV D2-"Medical Results and Discussion." The following discussion on asbestos is academic as there were no operations conducted during the survey which would generate excessive amounts of airborne asbestos fibers. Also, the request specified products used in the formulation of the detergent products and not insulation which may or may not contain asbestos.

Asbestos--The term asbestos refers to a group of silicates whose unusual properties have been known since antiquity. As early as 1918, the major North American insurance companies refused life coverage to asbestos workers. Numerous studies have shown that workers exposed to asbestos are liable to develop asbestosis, (gross thickening of lung tissues) and mesothelioma (a rare cancer of the lung lining). The carcinogenicity of asbestos is well known and is greatly increased in the smoker. The respiratory disabilities of those affected by asbestos exposure are severe, progressive and irreversible. The symptoms include increasing shortness of breath on exertion, slowly progressive reduction of pulmonary function, and progressive detrimental X-ray changes. The prognosis is poor for the worker with established asbestosis because there is no treatment that will affect the progressive lose of lung function. The NIOSH recommended

standard for asbestos of 100,000 fibers greater than 5 microns in length /M^3 is intended to (1) protect against the noncarcinogenic effects of asbestos, (2) materially reduce the risk of asbestos-induced cancer (only a ban can assure protection against carcinogenic effects of asbestos), and (3) be measured by techniques that are valid and reproducible. However, evaluation of all available human data provides no evidence for a threshold or for a "safe" level of exposure.

D. Evaluation Results and Discussion

1. Environmental Results and Discussion

Tables IA, IB, and IC show the analytical results for total or respirable dusts and sodium of all the personal and area samples obtained during operations in the South Tower facility. Tables IIA, IIB, and IIC show the analytical results for total or respirable dusts and sodium of all the personal and area samples obtained during operations in the North Tower facility. Each of the samples shown on these tables was also analyzed for boron. No boron (limit of detection-0.020 mg per filter) was detected on any of the filters. Hence, exposure to boron compounds at the time of the survey was minimal and did not present a hazard. From review of the tables, the results for respirable dusts varied from 0.1 to 0.6 mg/M^3 indicating some exposure to particulates in the respirable range which, from previous studies[15,16], may be indicative of the cause of some respiratory complaints. However, most of the dusts covered by the evaluation are in the large particulate or granular range and are in the non-respirable range. In considering airborne total dust results, it is noted that the products used are granular products which do not remain airborne for any long period of time but fall directly to the floor or equipment and accumulate. In fact, many of the particulates are probably to large to be effectively collected in the filter cassette. Although these large particulates do not present a problem from an inhalation standpoint, they do present a contamination problem on the hair, skin, and clothing of employees.

Twenty one of the 34 personal samples exceeded 1 mg/M^3 for the South Tower. The analytical results for nuisance particulates and sodium plus the calculated sodium carbonate and sodium bicarbonate concentrations of these 21 samples are contained in Table III. Two of the samples exceeded the environmental criteria of 10 mg/M^3 for total nuisance dusts with a maximum exposure of 31.7 mg/M^3 for the general worker no. 1. The maximum exposure of the general worker no. 1 to sodium carbonate and sodium bicarbonate was calculated as 11.13 mg/M^3 and 2.89 mg/M^3 respectively. Eight out of the 21 calculated sample results exceeded 1.0 mg/M^3 for sodium carbonate and two results exceeded the 1.0 mg/M^3 for sodium bicarbonate. For purposes of this report, exposures at or exceeding 1.0 mg/M^3 for sodium carbonate and sodium bicarbonate are considered as significant, and the exposures of the general worker no. 1 and the general relief worker may be considered as potentially toxic at the time of the survey.

Thirteen of the 34 personal samples exceeded 1 mg/M^3 for the North Tower. The analytical results for nuisance particulates and sodium plus the calculated sodium carbonate and sodium bicarbonate are contained in Table IV. None of the samples exceeded the environmental criteria of 10 mg/M^3 for total nuisance particulates. One out of the 13 calculated results (1.1 mg/M^3-crutcher operator) exceeded 1.0 mg/M^3 for sodium carbonate and no sample results exceeded 1.0 mg/M^3 for sodium bicarbonate.

Bendix detector tube measurements for carbon monoxide were obtained in appropriate areas of both the North and South Towers during the survey. Results for carbon monoxide indicated levels of less than 10 mg/M^3 which is well below the NIOSH recommended standard of 40 mg/M^3.

Six bulk samples of insulation from the North and South Towers were obtained and analysed for asbestos. The results of these samples are summarized below:

a) Bulk Sample #1 was obtained from the silicon tank, 5th floor North Tower, and contained 1-2 percent asbestos as amosite.

b) Bulk Sample #2 was obtained from the steam column by G-5, 5th floor of the North Tower, and no asbestos (less than 1 percent) was detected.

c) Bulk Sample #3 was obtained from the tower wall, 6th floor by nozzles of the North Tower, and no asbestos (less than 1 percent) was detected.

d) Bulk Sample #4 was obtained from the tower wall, 5th floor of the North Tower, and contained no asbestos (less than 1 percent) was detected.

e) Bulk Sample #5 was obtained from the wet scale, 5th floor of the South Tower, and contained 20-30 percent asbestos as amosite.

f) Bulk Sample #6 was obtained from the tower wall, 5th floor of the South Tower, and contained 2-5 percent asbestos as chrysotile and amosite.

No operations were observed during the survey which would generate airborne asbestos fibers. The company has been aware of the asbestos problem for several years and has an established asbestos program. They were also aware of the fact that insulation materials in both towers contained asbestos.

A cursory ventilation survey was made of some operations in the North and South Towers (NT & ST) using an Alnor Jr. Velometer and smoke tubes. Results indicated inadequate ventilation for the rework hood-ST, crutcher tanks-NT & ST, CMC hood-ST, dye weighing station-NT, and the perborate hood-NT. Not all of the overhead conveyor belts were provided with

enclosures and many of the conveyor belts with and without enclosures were not adequately maintained to preclude dusty conditions. There were many illustrations of dust accumulations on catwalks and other working or walking surfaces. Contamination was noted in various areas of both facilities as well as the skin, hair, and clothing of several employees. There were also several illustrations of inadequate maintenance of equipment such as doors not sealing properly on bins, holes in ventilation systems, inadequate seals, inadequate cleanup of conveyor belt enclosures, leaks in screening operation, doors to bins not shut, open containers full of rework material, and inoperable ventilation fans. The floors become extremely slippery when wet. The company provides outer clothing for employees (although they do not enforce the wearing of such clothing) as well as safety devices such as gloves and glasses. The company does not allow smoking, eating, or drinking in the production areas which are excellent practices and are enforced.

2. Medical Results and Discussion

a) Results of Medical Examinations and Questionnaires

An analysis of the completed questionnaires on the 30 workers involved in this health hazard evaluation detailed the following complaints:

1) Twenty one workers (70 percent of study participants) reported mucous membrane irritation. All 21 workers implicated carbonate products as the worst offender.

2) Twelve workers (40 percent of study participants) reported skin rashes. Ten workers felt that the carbonate products were the primary cause of their rash. Two workers attributed their skin problems to heat.

3) Eleven workers (37 percent of study participants) reported respiratory symptoms. These included shortness of breath (five individuals), cough (seven individuals), wheezing (two individuals). These figures indicate multiple respiratory complaints by some people. All 11 workers felt that carbonate products contributed significantly to their respiratory ills.

4) Eight workers (27 percent of study participants) reported excessive fatigue while on the job. Fatigue was noted only in dry powder production areas by the workers. When questioned further, it was noted by all eight workers that the fatigue was not exhaustive in nature, but rather a generalized dull, listless feeling, occurring as a rule when returning to work following the weekend. All eight workers felt that the carbonate products were the cause of their fatigue.

The vast majority of employees felt that environmental conditions were worse when processing carbonate products than when processing other

detergent products. Both the North and South Towers were processing carbonate products at the time of the survey. The answers to the question, "Do you know of other employees in your area who have had health problems or transferred for health reasons, or who died?", proved informative. Six workers noted the death or two of their workmates from the South Tower complex. These six workers stated both workers had died of lung cancer. Seven other positive responses were made in answer to this question. The answers detailed four person who suffered from skin rash/breathing problems, and in four instances persons who were transferred from dry powder production to the wet pack area due to allergy/skin rash.

The results of the physical examinations, performed on 28 Lever Brothers production workers, detailed clearly discernable mucous membrane irritation in a majority of the workers. Eye irritation/conjunctivitis affected 21 individuals; 75 percent of those examined. Twelve employees had apparent nose irritation (swollen, red, turbinates). They comprise 43 percent of those examined. Erythema (redness) of the throat was evident in 10 workers; 36 percent of those examined. Positive findings of skin irritation were apparent in nine workers, 32 percent of those examined. The skin irritation was confined to exposed skin areas. The most commonly affected areas were the skin folds about the nose, mouth, and nape of the neck. The carbonate formulations appear to be the primary agent responsible for these findings. This is most likely due to their strong alkalinity. Auscultation (listening) of the lungs of five individuals revealed rhonchi (abnormal lung sounds) in the upper lung fields. All five were current smokers averaging 20 cigarettes/day.

b) Medical/Records/Other Medical

Lever's medical records could not be obtained upon the initial request of NIOSH. In lieu of a potential stalemate with a resultant lack of company medical information, it was decided to review the company's medical records without personnel identifiers. A list of workers, including the two deceased workers' names, was submitted to Lever Brothers for medical record review purposes. Records for the two deceased individuals were in the "archives" and could not be located at the time of this survey. A review of the available records indicated a prevalence of skin rash and mucous membrane irritation as well as two individual reports of fatigue.

A salt tablet dispenser was noted in the waiting room of the medical clinic. The matter of salt supplementation during heat stress has been controversial for many years, and despite evidence to the contrary, it still has many adherents. It has long been realized that the indiscriminate use of salt tablets can lead to serious health consequences. A high salt concentration in the stomach may cause cramps, nausea, vomiting, and diarrhea. A high salt intake is, physiologically speaking, unnecessary even for a man sweating heavily, as salt balance can be maintained on daily intakes of 5 grams. It seems that the safest procedure is to replace salt losses at mealtimes. If salt must be replaced during heat stress, it should be taken in fluid form and preferably in concentrations not exceeding 0.3 percent salt.[1,2,4]

E. OBSERVATIONS AND CONCLUSIONS

The NIOSH investigators noted several examples (e.g., cleaning of clothing with compressed air, respirator program, short sleeved shirts, dry sweeping of dusts, no gloves, etc.) of poor general work and personal hygiene practices. Housekeeping needs improvement as evidenced by the several piles of products accumulating on floor areas due to leaks in the system or other reasons. During the survey, it was noted that several employees' hands and hair plus portions of their clothing were contaminated with products. The effects of chemicals on the skin and the absorption of some chemicals by the skin and uptake by the gastrointestinal tract via hand to mouth (e.g., cigarettes, food, etc.) activities are important considerations in assessing the overall potential exposure of employees. For instance, the natural secretions of the skin are acidic at a pH of 5.4 (neutral is pH of 7 on a scale of pH 1-14) and in extreme cases a pH may be as low as 4.0 This secretory mechanism plays an important role in protecting the skin against invading organisms or meterials and is commonly called the "acid mantle" of the skin. It follows that frequent contamination or washing of the skin with alkaline materials affects the natural protection or "acid mantle" of the skin and is not recommended. It appears evident that mere air sampling will not by itself provide an adequate measure of the occupational exposure to various chemicals, although that method is the only readily quantifiable measure of exposure. It is noted that safety glasses are not adequate protection for the eyes in dusty conditions or for these airborne particulates.

The dusts covered by this evaluation should not be considered as nuisance dusts due to their high alkalinity which characterized the overall alkaline environment in which employees are working. In this regard, the investigators felt the most practical method would be to characterize the bulk samples as to their alkalinity such as sodium hydorxide, sodium carbonate, and sodium bicarbonate. The main source of alkalinity in the analysis of the bulk samples was due to sodium carbonate and sodium bicarbonate. Hence, concentrations of these compounds were calculated and results are discussed in the body of the report. In view of the environmental results of the air samples plus visible contamination on several employees and the floor areas, as well as the medical results, it is concluded that environmental conditions are considered potentially toxic. It is noted that "carbonate" products are not always being processed in these facilities, and environmental conditions are subject to change. Also, dusty conditions are probably more prevalent during major cleanup, changeover, maintenance, and similar operations which were not covered by this evaluation.

In reviewing the literature covered in the references, there does not appear to be sufficient information on sodium carbonate or sodium bicarbonate to suggest an environmental level for airborne concentrations of these compounds. The medical results found during this evaluation appears to implicate "carbonate" products as being more toxic than other products processed in the North and South Tower facilities. The symptomotology noted by the employees was not only due to the airborne concentrations of alkaline materials, but also due to the effect (e.g., on the "acid mantle", etc.) of direct contact or contamination of the skin and mucous

membranes with various products being processed and the alkaline nature of the main products. Hence, additional environmental and medical studies on sodium carbonate and sodium bicarbonate are necessary before any suggested level or criteria be established for airborne concentrations of these compounds can be made. The medical results found during this evaluation appears to implicate "carbonate" products as toxic and could be attributable to absorption via the respiratory tract from airborne contamination or effects on the skin and the mucous membranes. It is concluded that environmental conditions are potentially toxic and additional environmental and toxicological studies on sodium carbonate and sodium bicarbonate are necessary before any further definitive statement should be made.

The two high sample results for the general worker number 1 and the general relief worker plus other sample results show potentially toxic concentrations for these two workers over the 3 day period of the survey. Because of the possibility of the two high samples being spiked and other reasons and considerations, no conclusions are made concerning the exposures of the general worker number 1 and the general relief worker. From the environmental results presented in Table I through IV as well as visual observations, it appears that employees are at a higher risk in the South Tower than employees in the North Tower.

Several employees expressed concern about the possible long-term effects of exposure to the detergent constituents. However, with the exception of asbestos, to the authors knowledge exposure to the contaminants involved in this evaluation does not result in long-term effects such as cancer and leukemia.

F. RECOMMENDATIONS

In the view of the above information showing that the dusts should not be considered as nuisance dusts due to their high alkalinity content and other considerations as well as the lack of and/or need of additional toxicological or other information on various chemicals, it is prudent to minimize potential exposures. The following recommendations are offered to provide a more desirable working environment for all personnel.

1. Review, evaluate, and make appropriate modification so the current engineering controls (e.g., ventilation, enclosures, etc.) in the Finishing Departments of both the North and South Towers. Changes to the current periodic maintenance program should be made to assure that the engineering controls are adequate, operational, and used as appropriate. This should include periodic checking and cleaning of emergency eyewash and shower facilities. Improved engineering controls and maintenance program should preclude the possible airborne contamination and accumulation of dusts. Conveyor belts or other means of transporting products should be enclosed to avoid products falling on employees and working areas.

2. An improved education program should be implemented so that employees are made aware of the toxicity and hazards plus the

proper precautions to be taken when handling materials used in operations covered by this evaluation. Good work practices and procedures should also be included in these practices. Certain operations (e.g., cleaning of bag house, screening, etc.) should require additional protective clothing (e.g., long sleeved shirts or coveralls, goggles, respirators, gloves, etc.) to preclude contamination of skin and eyes by dusts. Personal cleanliness and hygiene of employees (e.g., washing hands, changing clothes, etc.), contamination control, and use of protective clothing (e.g., respirators, gloves, goggles, etc.) should be stressed. The updating of the Material Safety Data Sheets on various chemicals used at the plant should continue to receive emphasis.

3. The company should evaluate and modify the respiratory protection program to assure that it is in compliance with the requirements (e.g., training, face fit, sanitation, etc.) described (outlined as 11 criteria for a "minimal acceptable program") in the Occupational Safety and Health Administration Standard, Title 29 of the Code of Federal Regulations, Part 1910, Section 134. It is our understanding that the dicalite operation is the only operation which requires the use of a respirator. It is felt that the requirements for wearing of respirators should be expanded to include other dusty operations such as cleanup. Although not required by management, employees were wearing respirators during some of these operations. Also, employees used respirator socks or were not freshly shaven (a few had beards), which made the use of a respirator ineffective. No individual with compromised lung function should be required to wear a respirator.

4. Management is encouraged to continue developing detailed written health and safety programs and instruct all employees as to the health hazards associated with the substances used in the facility and the proper usage of personal protective equipment. Personal protective equipment should be provided for employees exposed to health hazards which cannot be adequately abated by engineering controls. At no time should personal protective equipment preclude engineering controls. Contamination on any portion of the body should be avoided by employees. To prevent skin irritation, workers should wear long sleeved, loose fitting clothing which are provided by the company. Workers should rinse exposed skin areas frequently during the work day, and shower at the end of the day.

5. Better housekeeping is needed throughout both tower facilities.

6. Heat stress prevention can be accomplished by acclimatizing workers using a break in schedule for 1 to 2 weeks. Normal salt intake with meals is advised. Ample drinking water should be available at all times and should be taken frequently during the working

day. It may be necessary to conduct a heat stress survey and establish a more formal heat stress program for those operations where heat stress continues to be a problem. The indiscriminate dispensing of salt tablets should be discontinued.

7. Efforts on improving any potential problems concerning asbestos should receive continued emphasis by the Lever Brothers Company. Of particular interest concerning asbestos is the use of protective clothing, monitoring, respirators, disposal, etc., as covered by the requirements and/or recommendations contained in the Occupational Safety and health Standard, Title 29 of the Code of Federal Regulations, Part 1910, Section 1910.1001, entitled "Asbestos"; NIOSH Revised Recommended Asbestos Standard, December 1976, DHEW (NIOSH) Publication No. 77-169; and Sprayed Asbestos-Containing Materials in Buildings - A Guidance Document, Publication No. EPA 450/2-78-014.

8. The current company's policy of no smoking, eating, or food and beverages in the work areas is rigidly enforced by supervisors. The NIOSH investigators wholeheartedly endorse the company's policy on this matter, and encourage them to consider a similar policy on appropriate protective clothing for various operations in the tower facilities.

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TABLE IA
HHE 79-48

ENVIRONMENTAL RESULTS OF PERSONAL AND GENERAL AREA FILTER SAMPLES OBTAINED ON APRIL 10, 1979, DURING NORMAL PRODUCTION OPERATIONS IN THE SOUTH TOWER FACILITY, LEVER BROTHERS COMPANY, PAGEDALE, MO

Job and/or Area Classification	Sample Number	Time of Samples	Nuisance Particulates mg/M^3*	Sodium mg/M^3*
Tower Control Operator	D1759T **	0705-1405	0.3	0.05
Screener Operator	FW3124R	0530-1402	0.1	0.01
	FW3165T	0530-1402	0.2	0.03
Screener Helper	D1720T	0935-1403	3.0	0.66
Crutcher Operator	D1774T	0540-1310	1.6	0.49
Ducon Dye Operator	FW3140R	0715-1410	0.6	0.18
	FW3156T	0715-1410	2.0	0.58
Nozzler Operator	FW3109T	0710-1358	1.3	0.37
	FW3141R	0710-1358	0.2	0.08
General Worker #1	D1775T	0540-1406	31.7	6.19
Relief Operator	FW3164T	0525-1355	0.5	0.10
	FW3011R	0525-1355	0.1	0.02
General Worker	D1769T	0720-1355	3.5	0.81
General Worker-Relief	D1778T	0545-1411	3.2	0.58
Environmental Criteria for 40-hour workweek--Total Nuisance			10.0	--***
Respirable Nuisance Particulate			5.0	

*-mg/M^3--Approximate milligrams of substance per cubic meter of air.

**-------The letter D preceeding sample number indicates a DM-800 filter which is a vinyl chloride acrylonitrile filter. The letters FW preceeding sample number indicates a FWSB filter which is a polyvinyl chloride filter. The letter T after sample number indicates total particulate sample. The letter R after sample number indicates respirable particulate sample.

***------No environmental criteria or standards were suggested for sodium. Please refer to body of report for further information.

TABLE IB
HHE 79-48

ENVIRONMENTAL RESULTS OF PERSONAL AND GENERAL AREA FILTER SAMPLES OBTAINED ON APRIL 11, 1979, DURING NORMAL PRODUCTION OPERATIONS IN THE SOUTH TOWER FACILITY, LEVER BROTHERS COMPANY, PAGEDALE, MO

Job and/or Area Classification	Sample Number	Time of Sample	Nuisance Particulates mg/M^3*	Sodium mg/M^3*
Tower Control Operator	D8693T**	0715-1420	0.2	0.04
Screener Operator	D8553T	0720-1410	0.6	0.10
Screener Helper	D1587T	0725-1411	1.2	0.33
	FW3367T	0725-1411	1.5	0.36
Crutcher Operator	D1761T	0519-1322	1.1	0.33
	FW3146T	0519-1325	1.2	0.38
Ducon Dye Operator	D1766T	0532-1435	1.5	0.39
Nozzler Operator	FW3362T	0730-1416	0.9	0.23
General Worker #1	FW2995T	0517-1420	1.0	0.26
Relief Operator	D1767T	0514-1406	1.0	0.25
General Worker #2	D8489T	0732-1405	2.6	0.51
	D8496T	0732-1405	2.1	0.44
General Worker-Relief	D1772T	0523-1407	4.7	0.88
Area Sample-Tower Control Area	D1760T	0840-1337	0.5	0.13
	FW3122T	0840-1337	0.5	0.14
Area Sample-Screening Area	FW3013T	0556-1335	0.1	0.03
	D8865T	0556-1335	0.2	0.06
Area Sample-Crutcher Area	D1763T	0600-1331	1.6	0.44
Environmental Criteria for 40-hour workweek--Total Nuisance			10.0	--***
Respirable Nuisance Particulate			5.0	

*-mg/M^3--Approximate milligrams of substance per cubic meter of air.

**-------The letter D preceeding sample number indicates a DM-800 filter which is a vinyl chloride acrylonitrile filter. The letters FW preceeding sample number indicates a FWSB filter which is a polyvinyl chloride filter. The letter T after sample number indicates total particulate sample. The letter R after sample number indicates respirable particulate sample.

***------No environmental criteria or standards were suggested for sodium. Please refer to body of report for further information.

TABLE IC
HHE 79-48

ENVIRONMENTAL RESULTS OF PERSONAL AND GENERAL AREA FILTER SAMPLES OBTAINED ON APRIL 12, 1979, DURING MINIMAL CLEANUP OPERATIONS IN IN THE SOUTH TOWER FACILITY, LEVER BROTHERS COMPANY, PAGEDALE, MO

Job and/or Area Classification	Sample Number	Time of Sample	Nuisance Particulates mg/M^3*	Sodium mg/M^3*
Screener Operator	D8778T**	0730-1245	1.1	0.21
Screener Helper	FW3148T	0730-1247	6.3	1.11
Crutcher Operator	D1510T	0725-1301	0.6	0.12
Ducon Dye Operator	FW3114T	0735-1245	0.4	0.06
	D81532T	1045-1315	0.6	0.13
General Worker #2	D81489T	0740-1317	1.0	0.22
General Worker-Relief	D8863T	0740-1258	22.5	5.87
Environmental Criteria for 40-hour workweek--Total Nuisance Particulate			10.0	--***
Respirable Nuisance Particulate			5.0	

*-mg/M^3--Approximate milligrams of substance per cubic meter of air.

**-------The letter D preceeding sample number indicates a DM-800 filter which is a vinyl chloride acrylonitrile filter. The letters FW preceeding sample number indicates a FWSB filter which is a polyvinyl chloride filter. The letter T after sample number indicates total particulate sample. The letter R after sample number indicates respirable particulate sample.

***------No environmental criteria or standards were suggested for sodium. Please refer to body of report for further information.

TABLE IIA
HHE 79-48

ENVIRONMENTAL RESULTS OF PERSONAL AND GENERAL AREA FILTER SAMPLES OBTAINED ON APRIL 10, 1979, DURING NORMAL PRODUCTION OPERATIONS IN THE NORTH TOWER FACILITY, LEVER BROTHERS COMPANY, PAGEDALE, MO

Job and/or Area Classification	Sample Number	Time of Samples	Nuisance Particulates mg/M^3*	Sodium mg/M^3*
Tower Control Operator	FW3206R**	0520-1418	0.1	0.01
	FW3134T	0520-1418	0.1	0.02
Powder Controller Operator	FW3107R	0533-1408	0.1	0.01
	FW3118T	0533-1408	0.6	0.17
Crutcher Operator	D1765T	0529-1408	1.8	0.58
Ducon Dye Operator	D1776T	0527-1410	2.4	0.35
Nozzler Operator	D1779T	0545-1400	1.0	0.27
Tower Helper	FW3112R	0709-1413	0.1	0.01
	FW3116T	0709-1413	0.2	0.06
Relief Operator	D1764T	0704-1408	1.6	0.47
General Worker	D1762T	0720-1405	1.3	0.31
Production Worker	D1738T	0717-1400	6.5	0.28
Area Sample Base of Tower	D1768T	0808-1418	0.6	0.18
Area Sample By Hoods for Dicalite, etc.	D1706T	0820-1405	1.4	0.33
	FW3348T	0815-1405	1.2	0.25

Environmental Criteria for 40-hour workweek--Total Nuisance 10.0 ---***
Respirable Nuisance 5.0
Particulate

*-mg/M^3--Approximate milligrams of substance per cubic meter of air.

**-------The letter D preceeding sample number indicates a DM-800 filter which is a vinyl chloride acrylonitrile filter. The letters FW preceeding sample number indicates a FWSB filter which is a polyvinyl chloride filter. The letter T after sample number indicates total particulate sample. The letter R after sample number indicates respirable particulate sample.

***------No environmental criteria or standards were suggested for sodium. Please refer to body of report for further information.

TABLE IIB
HHE 79-48

ENVIRONMENTAL RESULTS OF PERSONAL AND GENERAL AREA FILTER SAMPLES OBTAINED ON APRIL 11, 1979, DURING NORMAL PRODUCTION OPERATIONS IN THE NORTH TOWER FACILITY, LEVER BROTHERS COMPANY, PAGEDALE, MO

Job and/or Area Classification	Sample Number	Time of Samples	Nuisance Particulates mg/M3*	Sodium mg/M3*
Tower Control Operator	D1777T**	0705-1415	0.3	0.07
Powder Controller Operator	D1773T	0718-1405	0.5	0.11
Crutcher Operator	D1790T	0716-1405	0.4	0.09
	FW3149T	0716-1405	0.4	0.06
Ducon Dye Operator	D1792T	0713-1405	1.9	0.26
	FW3374T	0713-1405	1.6	0.23
Nozzler Operator	FW3366T	0725-1410	0.8	0.20
Tower Helper	D8768T	0708-1416	0.5	0.13
Relief Operator	FW3105R	0800-1417	0.1	0.01
	FW3361T	0720-1417	0.2	0.04
General Worker	FW3368R	0702-1410	0.2	0.05
Production Worker	D8685T	0733-1410	2.9	0.17
	FW3154T	0733-1410	3.4	0.18
Area Sample-Crutcher	D1800T	0756-1405	0.3	0.08
Area Sample-Screw Conveyor Area	D8497T	0756-1405	1.2	0.33
Environmental Criteria for 40-hour workweek--Total Nuisance Particulate			10.0	--***
Respirable Nuisance Particulate			5.0	

*-mg/M^3--Approximate milligrams of substance per cubic meter of air.

**-------The letter D preceeding sample number indicates a DM-800 filter which is a vinyl chloride acrylonitrile filter. The letters FW preceeding sample number indicates a FWSB filter which is a polyvinyl chloride filter. The letter T after sample number indicates total particulate sample. The letter R after sample number indicates respirable particulate sample.

***------No environmental criteria or standards were suggested for sodium. Please refer to body of report for further information.

TABLE IIC
HHE 79-48

ENVIRONMENTAL RESULTS OF PERSONAL AND GENERAL AREA FILTER SAMPLES OBTAINED ON APRIL 12, 1979, DURING MINIMAL CLEANUP OPERATIONS IN THE NORTH TOWER FACILITY, LEVER BROTHERS COMPANY, PAGEDALE, MO

Job and/or Area Classification	Sample Number	Time of Samples	Nuisance Particulates mg/M^3*	Sodium mg/M^3*
Tower Control Operator	D1797T**	0718-1245	1.5	0.39
Powder Controller Operator	FW3126T	0715-1245	0.5	0.09
Crutcher Operator	D1785T	0712-1245	0.5	0.07
Ducon Dye Operator	D1802T	0718-1245	0.6	0.10
Nozzler Operator	FW3175T	0708-1205	0.7	0.15
Tower Helper	D1662T	0705-1205	0.4	0.13
Relief Operator	D8783T	0742-1205	0.4	0.07
General Worker	FW3111T	0710-1205	1.0	0.20
Production Worker	D81602T	0708-1205	1.2	0.11
Environmental Criteria for 40-hour workweek--Total Nuisance			10.0	--***
Respirable Nuisance Particulate			5.0	

*-mg/M^3--Approximate milligrams of substance per cubic meter of air.

**-------The letter D preceeding sample number indicates a DM-800 filter which is a vinyl chloride acrylonitrile filter. The letters FW preceeding sample number indicates a FWSB filter which is a polyvinyl chloride filter. The letter T after sample number indicates total particulate sample. The letter R after sample number indicates respirable particulate sample.

***------No environmental criteria or standards were suggested for sodium. Please refer to body of report for further information.

TABLE III

SUMMARY OF ENVIRONMENTAL RESULTS OF PERSONAL FILTER SAMPLES EXCEEDING 1 mg/M^3* OF TOTAL NUISANCE PARTICULATES DURING NORMAL PRODUCTION OPERATIONS ON APRIL 10-11, 1979, AND DURING MINIMAL CLEANUP OPERATIONS ON APRIL 12, 1979, IN THE SOUTH TOWER FACILITY, LEVER BROTHERS COMPANY, PAGEDALE, MISSOURI-HHE 79-48

Date	Job and/or Area Classification	Sample Number**	Time of Sample	Nuisance Particulates mg/M^3	Sodium mg/M^3	Sodium Carbonate*** mg/M^3	Sodium Bicarbonate*** mg/M^3
04/10/79	Screener Helper.	D1720T	0935-1403	3.0	0.66	1.19	0.31
04/10/79	Crutcher Operator	D1774T	0540-1310	1.6	0.49	0.88	0.23
04/10/79	Ducon Dye Operator	FW3156T	0715-1410	2.0	0.58	1.04	0.27
04/10/79	Nozzeler Operator	FW3109T	0710-1358	1.3	0.37	0.67	0.17
04/10/79	General Worker #1	D1775T	0540-1406	31.7	6.19	11.13	2.89
04/10/79	General Worker #2	D1769T	0720-1355	3.5	0.81	1.46	0.38
04/10/79	General Worker-Relief	D1778T	0545-1411	3.2	0.58	1.04	0.27
04/11/79	Screener Helper	D1587T	0725-1411	1.2	0.33	0.59	0.15
04/11/79	Screener Helper	FW3367T	0725-1411	1.5	0.36	0.65	0.17
04/11/79	Crutcher Operator	D1761T	0519-1322	1.1	0.33	0.59	0.15
04/11/79	Crutcher Operator	FW3146T	0519-1325	1.2	0.38	0.68	0.18
04/11/79	Ducon Dye Operator	D1766T	0532-1435	1.5	0.39	0.70	0.18
04/11/79	General Worker #1	FW2995T	0517-1420	1.0	0.26	0.47	0.12
04/11/79	Relief Operator	D1767T	0514-1406	1.0	0.25	0.45	0.12
04/11/79	General Worker #2	D8489T	0732-1405	2.6	0.51	0.92	0.24
04/11/79	General Worker #2	D8496T	0732-1405	2.1	0.44	0.79	0.21
04/11/79	General Worker-Relief	D1772T	0523-1407	4.7	0.88	1.58	0.42
04/12/79	Screener Operator	D8778T	0730-1245	1.1	0.21	0.38	0.10
04/12/79	Screener Helper	FW3148T	0730-1247	6.3	1.11	2.00	0.52
04/12/79	General Worker #2	D81489T	0740-1317	1.0	0.22	0.40	0.10
04/12/79	General Worker-Relief	D8863T	0740-1258	22.5	5.87	10.56	2.74
Environmental Criteria for 40-hour workweek----------Total Nuisance 10.0					--****	--****	--****

*-mg/M^3--Approximate milligrams of substance per cubic meter of air.

**-------The letter D preceeding sample number indicates a DM-800 filter which is a vinyl chloride acrylonitrile filter. The letters FW preceeding sample number indicates a FWSB filter which is a ploy vinyl chloride filter. The letter T after sample number indicates total particulate sample. The letter R after sample number indicates respirable particulate sample.

***------The results for sodium carbonate and sodium bicarbonate reported above are not actual analytical results for these compounds but rather calculated values based upon actual analytical results for sodium. Please refer to body of report and Appendix A for further details.

****-----No environmental criteria or standards were suggested for sodium, sodium carbonate, and/or sodium bicarbonate.

TABLE IV

SUMMARY OF ENVIRONMENTAL RESULTS OF PERSONAL FILTER SAMPLES EXCEEDING 1 mg/M^3* OF TOTAL NUISANCE PARTICULATES DURING NORMAL PRODUCTION OPERATIONS ON APRIL 10-11, 1979, AND DURING MINIMAL CLEANUP OPERATIONS ON APRIL 12, 1979, IN THE NORTH TOWER FACILITY, LEVER BROTHERS COMPANY, PAGEDAGE, MISSOURI-HHE 79-48

Date	Job and/or Area Classification	Sample Number**	Time of Sample	Nuisance Particulates mg/M^3	Sodium mg/M^3	Sodium Carbonate*** mg/M^3	Sodium Bicarbonate*** mg/M^3
04/10/79	Crutcher Operator	D1765T	0529-1408	1.8	0.58	1.10	0.25
04/10/79	Ducon Dye Operator	D1776T	0527-1410	2.4	0.35	0.67	0.15
04/10/79	Nozzler Operator	D1779T	0545-1400	1.0	0.27	0.51	0.12
04/10/79	Relief Operator	D1764T	0704-1408	1.6	0.47	0.89	0.20
04/10/79	General Worker	D1762T	0720-1405	1.3	0.31	0.59	0.13
04/10/79	Production Worker	D1738T	0717-1400	6.5	0.28	0.53	0.12
04/11/79	Ducon Dye Operator	D1792T	0713-1405	1.9	0.26	0.50	0.11
04/11/79	Ducon Dye Operator	FW3374T	0713-1405	1.6	0.23	0.44	0.10
04/11/79	Production Worker	D8685T	0733-1410	2.9	0.17	0.32	0.07
04/11/79	Production Worker	FW3154T	0733-1410	3.4	0.18	0.32	0.08
04/12/79	General Worker	FW3111T	0710-1205	1.0	0.20	0.38	0.09
04/12/79	Production Worker	D81602T	0708-1205	1.2	0.11	0.21	0.05
04/12/79	Tower Control Operator	D1797T	0718-1245	1.5	0.39	0.74	0.17
Environmental Criteria for 40-hour workweek----------Total Nuisance				10.0	--****	--****	--****

*-mg/M^3--Approximate milligrams of substance per cubic meter of air.

**-------The letter D preceeding sample number indicates a DM-800 filter which is a vinyl chloride acrylonitrile filter. The letters FW preceeding sample number indicates a FWSB filter which is a polyvinyl chloride filter. The letter T after sample number indicates total particulate sample. The letter R after sample number indicates respirable particulate sample.

***------The results for sodium carbonate and sodium bicarbonate reported above are not actual analytical results for these compounds but rather calculated values based upon actual analytical results for sodium. Please refer to body of report and Appendix A for further details.

****-----No environmental criteria or standards were suggested for sodium, sodium carbonate, and/or sodium bicarbonate.

APPENDIX A

EXAMPLES OF CALCULATIONS FOR SODIUM CARBONATE AND SODIUM BICARBONATE CONCENTRATIONS FOR THE NORTH TOWER FACILITY AND THE SOUTH TOWER FACILITY

I. North Tower Facility

The average analytical result of the bulk samples was 21.55 percent carbonate ($CO_3^{=}$), 6.225 percent bicarbonate (HCO_3^{-}), and 20.00 percent sodium (Na^{+}). This would result in percentages among only these compounds (e.g., total percent of partial percentages) of 45.11 percent for $CO_3^{=}$, 13.03 percent for HCO_3^{-}, and 41.86 percent for sodium. For example, 21.55 + 20.0 + 6.225 = 47.775 percent; and for $CO_3^{=} = \frac{21.55\%}{47.775\%} =$ 0.4511 or 45.11 percent $CO_3^{=}$. In calculating the carbonate concentration use:

$$\frac{0.4186(\%\ Na^{+})}{0.4511(\%\ CO_3^{=})} = \frac{mgNa^{+}}{x};\ = 1.0776 \times mgNa^{+} = \text{amount of } CO_3^{=} \text{ ion.}$$

$$\frac{mgNa^{+} \times 1.0776 \times 106\ (\text{Molecular Weight of Sodium Carbonate - } Na_2CO_3)}{60\ (\text{Molecular Weight } CO_3^{=})} =$$

$$1.904 \times mgNa^{+} = \text{mg of sodium carbonate.}$$

Hence, if the actual analysis of the filter sample was 0.50 mg/M^3 for sodium, this would result in a concentration of sodium carbonate (Na_2CO_3) of 1.904 x 0.5 = 0.95 mg/M^3 of Na_2CO_3. Similar calculations for sodium bicarbonate ($NaHCO_3$) show a conversion factor of 0.4287 x $mgNa^{+}/M^3$ = mg/M^3 of sodium bicarbonate.

Example: $\frac{0.1303 \times mgNa^{+}}{0.4186} = 0.3113 \times mgNa^{+}$ = bicarbonate concentration

$$\frac{mgNa^{+}\ 0.3113 \times 84\ (\text{Molecular Wt } NaHCO_3)}{61\ (\text{Molecular Wt } HCO_3^{-})} = 0.4287 \times mgNa^{+} = mgNaHCO_3$$

II. South Tower Facility

The average analytical result of the bulk samples was 19.425 percent carbonate ($CO_3^{=}$), 6.6 percent bicarbonate (HCO_3^{-}) and 19.5 percent sodium (Na^{+}). This would result in percentages among only these compounds (e.g., total percentages of partial percentages) of 42.67 percent for $CO_3^{=}$, 14.50 percent for HCO_3^{-}, and 42.83 percent for Na^{+}. For example, 19.425 + 6.6 + 19.5 = 45.525 percent and for $CO_3^{=} = \frac{19.425}{45.525} = 0.4267$ or 42.67 percent $CO_3^{=}$.

The following conversion factors for the South Tower were arrived at based upon those factors presented for the North Tower above.

A. Concentration of Na_2CO_3 = 1.7983 x $mgNa^+/M^3$ = mg/M^3 of sodium carbonate.

B. Concentration of $NaHCO_3$ = 0.4661 x $mgNa^+/M^3$ = mg/M^3 of sodium bicarbonate.

The above explains how the concentrations of Na_2CO_3 and $NaHCO_3$ were calculated based on the analytical results of sodium as mg/M^3 for the North and South Towers respectively.