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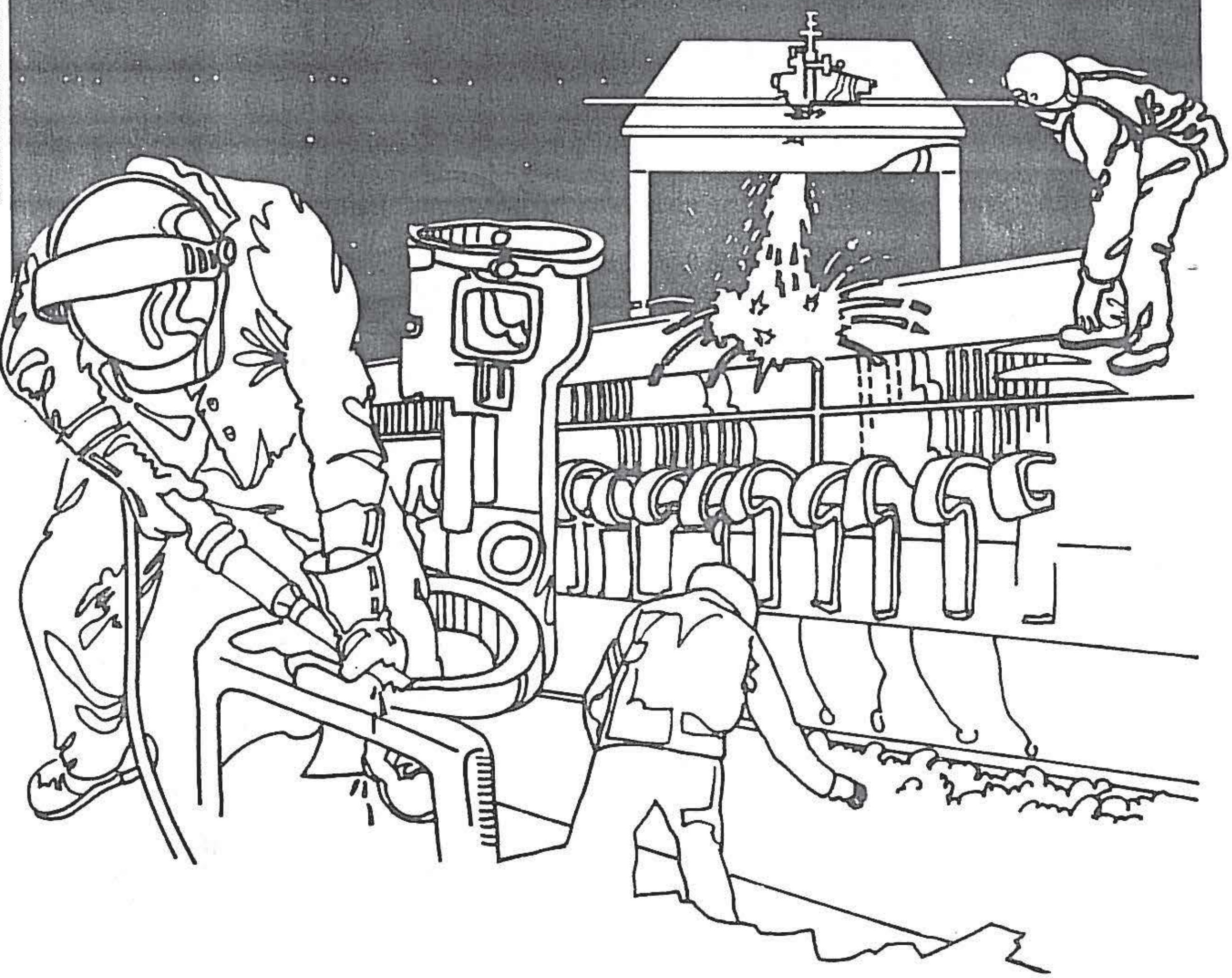

# Health Hazard Evaluation Report

HETA 80-086-1191
HARBISON-WALKER REFRACTORIES
FAIRFIELD, ALABAMA
BESSEMER, ALABAMA

## 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.

HE 80-86-1191
SEPTEMBER, 1982
HARBISON-WALKER REFRACTORIES
FAIRFIELD, ALABAMA
BESSEMER, ALABAMA

NIOSH INVESTIGATORS:
S. Salisbury, CIH
J. Melius, M.D.

## I. SUMMARY


On March 11, 1980, the National Institute for Occupational Safety and Health (NIOSH) received a health hazard evaluation request from the Sub-District Director, District 36, United Steelworkers of America. Members of United Steelworkers Locals 553 and 531, who worked for the Harbison-Walker (H-W) Refractories at Fairfield and Bessemer, Alabama, were concerned about possible health risks from exposure to airborne dusts containing aluminum oxide and free silica. These H-W plants manufacture refractory brick, used primarily by the steel industry. Approximately 40 of the 144 workers employed at the Fairfield Plant work in the Production Department. The Bessemer Plant has approximately 100 workers with 25 working in production.

During August and November, 1980, NIOSH conducted an industrial hygiene survey. We collected personal and general area air samples for measurements of total and respirable dust, respirable free silica, and aluminum oxide. Of the 6 samples taken at the Fairfield Plant, total dust concentrations ranged from 0.22 mg/M$^3$ to 2.92 mg/M$^3$; aluminum oxide levels ranged from 0.1 to 0.7 mg/M$^3$; and respirable dust exposures ranged from 0.04 mg/M$^3$ to 0.87 mg/M$^3$. As respirable free silica, exposures monitored ranged from 4.2 ug/M$^3$ to 91 ug/M$^3$. Only one production worker, the Screen Tender, was exposed in excess of the NIOSH recommended limit for respirable free crystalline silica (50 ug/M$^3$). At the Bessemer Plant, total dust concentrations ranged from 1.47 mg/M$^3$ to 50.63 mg/M$^3$; aluminum oxide levels from 0.1 to 7.9 mg/M$^3$; and respirable dust exposures from 0.1 mg/M$^3$ to 9.04 mg/M$^3$. Only two production worker exposures to respirable free silica may have exceeded 50 ug/M$^3$, the worker sacking castables (<77 ug/M$^3$) and the Larry Car Operator (<143 ug/M$^3$). Five of 11 samples taken from the Bessemer Plant were above the criteria for nuisance dusts and/or aluminum oxide (10mg/M$^3$).

The medical survey consisted of an initial medical interview with fifteen employees at the plants, and a later review of the pulmonary function testing and X-ray findings of medical screening previously done by the company. The medical interviews revealed a high prevalence of symptoms of respiratory irritation among the workers. Review of the available X-ray and pulmonary function findings on 174 workers found no indication of silicosis or other definitely work related respiratory disease among the workers.

NIOSH has determined that exposures to airborne dust for the Larry Car Operator and for workers packaging refractory castables at the Bessemer Plant exceeded the evaluation criteria for nuisance dust and aluminum oxide. Exposures to respirable free silica were not significant because of the low free silica content of the raw materials used. No indication of silicosis or other definitely work-related respiratory disease was found. Recommendations are provided in Section VIII of this report.



Keywords: SIC 3255 (Clay Refractories), refractory brick, bauxite, silica, aluminum oxide, nuisance dusts, silicosis

## II. INTRODUCTION

On March 11, 1980, The National Institute for Occupational Safety and Health (NIOSH) received a request for a NIOSH health hazard evaluation from the Sub-District Director, District 36, United Steelworkers of America, on behalf of members of United Steelworkers, Local 553 and Local 531. The union was concerned about the possible health risks for workers exposed to dust during the production of refractory bricks at the Harbison-Walker (H-W) Refractories at Fairfield (Local 553) and Bessemer (Local 531), Alabama. The union also stated that a number of disabling lung diseases had been reported under workers compensation claims by retired H-W employees. The union members believed these lung problems were the result of the long term occupational dust exposures at the plants. Management had notified the union that atmospheric sampling of the dusty work areas had shown dust levels to be within acceptable limits. The workers were told the dust was mostly aluminum oxide, a "nuisance" dust which did not present a serious health hazard for exposed workers. The union, questioning H-W's findings, requested a NIOSH Health Hazard Evaluation.

In response to this request, NIOSH conducted an initial survey on April 8-9, 1980. During the initial survey an opening conference was held at both the Bessemer and Fairfield plants. Those attending these meetings included: the NIOSH medical and environmental investigators; the President, United Steelworkers Sub-District 36; the United Steelworkers Sub-district 36 Safety and Health Coordinator; the H-W Corporate Safety Director; the H-W Environmental Safety and Health Coordinator; and other local union and H-W management personnel representing the Bessemer and/or Fairfield plants. Information was obtained by the NIOSH industrial hygienist concerning the manufacturing processes, work practices and schedules, materials used, and the number of workers assigned to each production area. The NIOSH physician conducted informal non-directed interviews with many of the production workers. A closing conference was held with management and union representatives to discuss NIOSH plans for conducting a follow-up environmental/medical investigation to evaluate potential health effects for production workers exposed to dusts containing aluminum oxide and free silica.

A follow-up industrial hygiene survey was conducted on August 6-8, 1980. Atmospheric samples were collected for total dust, aluminum oxide, respirable dust, and respirable free silica. A report (Interim Report No. 1) with preliminary findings and recommendations was submitted to the union and to H-W management personnel on October 30, 1980. Additional dust samples were collected by NIOSH on November 6, 1980, during a brick "grinding and sizing" process which was not operating during the previous NIOSH survey. The environmental results from the industrial hygiene surveys were provided to management and union representatives (Interim Report No. 2) on April 22, 1981.

On February 12, 1982, a NIOSH physician reviewed the pulmonary function test results and chest X-rays which had been recently completed for all H-W production workers at the Bessemer and Fairfield plants by the Alabama Industrial Health Council of Birmingham, Alabama. The results of this review were summarized in a letter to the union (Locals 531 and 553) and to the H-W Personnel Manager on February 25, 1982.

## III. BACKGROUND

The H-W plants at Fairfield and Bessemer, Alabama, manufacture refractory brick from a blend of bauxite, high grade aluminum oxide, and clay. The Fairfield Plant began producing brick in 1908 and was automated in 1950. The plant produced a high silica content brick until 1966. Since 1966, the plant has manufactured brick with a high alumina composition. The principal product is sold under the trade name, UFALA, and is composed of UCAL 60 bauxite (60% $Al_2O_3$), M & D Ball Clay, Kaolex D6, and, calcine alumina A2 (99% $Al_2O_3$). Materials are shipped to the plant by rail car. Clays, A2 alumina, and Kaolex D6 are unloaded pneumatically and stored in silos. Bauxite is dumped from rail cars onto a conveyer. If necessary, it is dried before being sent into the plant where it is crushed, sized, and blended with clays, alumina, and water to make the compound which is formed into bricks in a hydraulic press. The brick press operators then remove the bricks and stack them on rail carts for firing in a tunnel kiln. Approximately 40 of the 144 workers employed at the Fairfield plant work in the Production Department.

The Bessemer Plant has approximately 100 workers, with 25 working in production, and has been in operation since 1925. This plant produces a brick composed of UCAL 70 bauxite (70% $Al_2O_3$), M & D Ball Clay, and calcine alumina A2. Brick produced at the Bessemer plant is sold under the trade name ALUSA. Clay and A2 alumina are offloaded from rail cars into silos using the type of pneumatic system operating at the Fairfield Plant. At the Bessemer Plant, bauxite is not directly offloaded onto a conveyer system as is done at the Fairfield Plant. The ore is dumped from rail cars into large stalls and the material is then loaded onto the conveyer with a front-end loader truck.

Production processes at both plants are similar but the Fairfield Plant is a more modern facility which utilizes an electronic (Richardson) mixing system. The mixing system is a fully enclosed process which produces considerably less dust by comparison to the older, manually operated "larry car" mixing system used at the Bessemer Plant.

Bi-annual physicals are given to all H-W workers by the Alabama Industrial Health Council. A mobile medical van is used to provide chest X-ray (on 70mm film), blood and urine tests, pulmonary function tests, audiometric and vision tests, blood pressure, and EKG's for workers over 40. If health screening detects a problem, workers are re-checked and if necessary, referred to their personal physician. Feedback from the physician to the Council is required on all referrals. A notification letter is also sent to the employer but medical records are maintained by the Council and released to the employer only if authorized by the employee. H-W plants at Bessemer and Fairfield were scheduled for worker health screening in February, 1981.

## IV. EVALUATION DESIGN AND METHODS

### A. Initial Survey (April 8-9, 1980)

The primary objectives of the initial survey were to identify the production processes with the greatest potential for airborne dust exposure and to gain a better understanding of the types of dusts released by these processes. The H-W Quality Control Supervisor provided NIOSH with the mineralogic composition of the raw materials used to produce the UFALA and ALUSA refractory bricks and the basic composition of the major raw materials used at the Fairfield and Bessemer plants. The frequency and duration of worker exposures to brick dusts were determined by reviewing H-W production schedules and by informally interviewing the employees working in dusty areas. Employees were also asked to identify production areas or processes which had caused them the greatest concern regarding possible adverse health effects.

Fifteen current employees were interviewed by a NIOSH physician regarding possible work-related health complaints.

### B. Follow-up Environmental Surveys (Aug. 6-8 and Nov. 6, 1980)

A review of environmental monitoring records provided by H-W identified several jobs with a history of high dust level exposures. At the Bessemer plant these jobs include: the Bin Man, the Larry Car Operator, and the Dry Pan Operator; at the Fairfield plant, the Screen Tender, and general laborers who dumped sacks of materials in the Richardson mixer bins. The company was providing NIOSH approved respirators for workers performing these jobs. According to company records of previous industrial hygiene surveys conducted by the insurance carrier in 1975 and 1977, the percentage of free silica in dust samples collected at the Fairfield plant, as determined by X-ray diffraction analysis, ranged from 9-21% as total dust or 5% as respirable dust. Samples collected by the insurance carrier from the Bessemer plant were reported to contain 7-11% free silica as total dust or 18% as respirable dust. Respirable dust samples collected at the Bessemer plant in 1979 by the H-W Environmental Health and Safety Coordinator (the H-W Corporate Industrial Hygienist), were found to contain from less than 1% to 8.8% free silica.

At the time of the NIOSH survey H-W had recently installed a new raw materials bulk handling system at the Fairfield Plant which eliminated the job requiring workers to manually dump sacks of materials directly into the Richardson mixer. Although H-W had been actively improving engineering controls to reduce dust exposures, NIOSH investigators believed potentially hazardous airborne concentrations of silica containing dusts might be present in some work areas.

A follow-up environmental survey was conducted on August 6-8, 1980, in order to conduct atmospheric sampling for total dust, aluminum oxide, respirable dust, and respirable free silica.

On August 6th, 6 personal and 5 area samples were collected at the Fairfield Plant. Jobs sampled included the Screen Tender who was responsible for operating the pneumatic bulk materials handling system, two Raw Materials Handlers working on the rail car unloading dock, and the Tram Rail Operator who transports material from the Richardson mixer to the brick presses. Two personal samples were also taken for workers operating a brick grinding and sizing machine.

The Bessemer Plant was sampled on August 7th. Jobs sampled were: Two Raw Materials Handlers; general laborers cleaning out a bucket elevator containing High Duty Fire Clay (not a routine job); the Front-end Loader Operator and a Raw Materials Handler loading a jaw crusher with bats (discarded, damaged, or undersized bricks); the Larry Car Operator; the Dry Pan Operator; and the Mixer/Pug Mill Operator. Area samples were taken near the dry pan, the shuttle conveyer, and the Larry Car. We also sampled the "refractory castibles" bin loading and bagging operation for two hours during the second shift by taking personal air samples from the Bagger Operator and from a worker cracking and dumping sacks of calcine aluminate cement in the Larry Car room. According to one of the workers, the high concentration of airborne dust generated during this bagging operation was worse on the second shift because materials were loaded in the top of the holding bin at the same time materials were dispensed into sacks at the bottom of the bin.

Personal dust samples were collected using battery operated air sampling pumps calibrated to pull 1.7 liters of air per minute (LPM). Total dust samples were collected on 0.5 micron (u) 37mm (type M-5, Mfg. by Millipore Corp.) filters mounted in 2 piece plastic cassettes attached to the workers' shirt collar. Respirable dust was collected by pulling air at 1.7 LPM through miniature (10mm) nylon cyclones designed to separate coarse dust (non-respirable) from fine dust (respirable dusts with particle sizes less than 10 microns in diameter). The cyclones were fastened to the front of the worker's shirt and respirable dust was trapped on M-5 filters mounted in 2-piece plastic cassettes. Each worker sampled wore both types of sampling devices. Total dust sample filters were analyzed gravimetrically. The samples were analyzed for aluminum content by atomic absorption spectroscopy in accordance with NIOSH P & CA Method No. 173. Respirable dust sample filters were analyzed gravimetrically for respirable dust and for respirable free silica, as quartz and/or cristobalite, by X-ray diffraction using NIOSH P & CA Method 259, with modifications. For most personal respirable dust exposures, the amount of dust collected was quantitatively too small for silica analysis, especially for samples containing aluminum which interferred with the X-ray diffraction determination. In personal samples, where quantitation was possible, the amount of free silica was reported as micrograms of quartz or cristobalite per sample.

X-ray diffraction methods were also used to analyze bulk samples (settled dust) of raw and mixed refractory brick materials to determine the percent quartz and/or cristobalite. Bulk air (high air volume) samples were collected in the work areas as close as possible to where personal samples were collected and in locations where high dust concentrations were expected. These samples were collected as respirable dust and/or total dust on 37mm M-5 filters at flow rates of 3.5 or 9 LPM and were analyzed by X-ray diffraction for the percent free silica as quartz or cristobalite. Whenever possible, the percent free silica values obtained from the bulk air respirable dust samples were used in computing the permissible exposure limit for personal exposures to respirable dusts using the respirable mineral dust formula (see Section V); otherwise, an average of the values found in the appropriate bulk air total dust samples or bulk settled dust samples were used in the calculations.

C. Follow-up Medical Records Review (February 12, 1982)

The follow-up medical evaluation consisted of the review of pulmonary function testing and chest X-ray results from the medical screening recently conducted for Harbison-Walker employees at both the Fairfield and Bessemer Plants by the Industrial Health Council of Birmingham. Information reviewed included pulmonary function test results on 88 Fairfield Plant and 86 Bessemer Plant employees. This testing included three test trials for each employee with appropriate age and height adjustment of the test results. Each individual record was abstracted by a NIOSH physician to obtain age, $FEV_1$% predicted, FVC% predicted, and the clinical interpretation. The worker's seniority at the plant was obtained from plant personnel lists. The H-W personnel manager also provided, if available, a current smoking history for each worker.

The chest X-rays were standard 70mm screening films. Workers with abnormalities on their screening X-ray were notified and offered standard clinical chest X-rays at the Industrial Health Council. For this reason, all X-ray records were requested for the 20 workers with the greatest seniority at the plant and for 10 less senior workers with restrictive findings on their pulmonary function tests. The standard clinical chest X-rays were reviewed, if available. In addition, a list of workers with abnormal 70mm chest X-rays at the most recent screening was obtained, and their follow-up files and X-rays were reviewed.

## V. EVALUATION CRITERIA

### A. Environmental Criteria

The environmental criteria described below are intended to represent airborne concentrations of substances to which workers may be exposed for eight hours a day, 40 hours per week for a working lifetime without adverse health effects. Because of wide variation in individual susceptibility, a small percentage of workers may experience discomfort from some substances at concentrations at or below the recommended criteria.[1] A smaller percentage may be more seriously affected by aggravation of a pre-existing condition or by a hypersensitivity reaction. The time-weighted average (TWA) exposure refers to the average concentration during a normal 8-hour workday. The Short-Term Exposure Limit (STEL) is the maximum allowable concentration, or ceiling, to which workers can be exposed during a period of up to 15 minutes, provided that no more than four excursions per day are permitted, with at least 60 minutes between exposure periods.

The primary sources of environmental evaluation criteria considered for this study were: 1) NIOSH criteria documents and recommendations, 2) the American Conference of Governmental Industrial Hygienists (ACGIH) Threshold Limit Values (TLV's),[1] and 3) the U.S. Department of Labor (OSHA) Federal Occupational Health Standards.[2] The selection of the appropriate criteria for this study is based on the composition of the brick and on the raw materials used to produce the brick. The high alumina refractory brick produced by H-W at the Fairfield and Bessemer plants is mostly composed of aluminum oxides; combined silica, bound to one or more other oxides; and variable amounts of free silica, as quartz (in green brick) or cristobalite (in fired brick). The criteria judged most appropriate for this study are as follows:

| Substance | Short Term Exposure Limits | 8 - 10 Hour Time Weighted Average | Source |
|---|---|---|---|
| Nuisance Dusts (containing less than 1% free silica) (e.g. bauxite) | | | |
| -total dust | | 10 mg/M3 | ACGIH |
| -respirable dust | | 5 mg/M3 | ACGIH |
| -total dust | | 15 mg/M3 | OSHA |
| -respirable dust | | 5 mg/M3 | OSHA |
| Aluminum Oxide | 20 mg/M3 | 10 mg/M3 | ACGIH |
| (as nuisance dust) | | 15 mg/M3 | OSHA |
| Resp. Free Silica | - | 50 ug/M3 | NIOSH |
| Resp. Quartz | - | 10 mg/M3 ÷ (% quartz + 2) | OSHA |
| Resp. Cristobalite | one half the value calculated from the above formula for quartz | | OSHA |

NOTE: mg/M3 = milligrams per cubic meter of air
ug/M3 = micrograms per cubic meter of air

B. Toxicity

The adverse health effects from excess exposure (exposures to airborne concentrations above the evaluation criteria) are summarized below:

1. Bauxite

Long experience with mining and refining of bauxite has not revealed significant adverse effects. Only a single report from Germany, written in 1955, describes pulmonary changes in workers exposed to bauxite dust in mines, foundries, and factories. Pulmonary changes were found in 3.5% of those exposed to bauxite dust but no progression was noted after 2 years of study. The exposures studied also represented conditions which are not typical of conditions existing today in plants which have reduced exposures through improved engineering controls.[3]

Bauxite is considered a nuisance dust having little adverse effects on the lungs and does not produce significant organic disease or toxic effects when exposures are kept below reasonable levels (i.e. 10mg/$M^3$).[4] The nuisance dusts have been called (biologically) "inert" dusts, but this term is inappropriate because any dust will evoke some cellular response in the lungs when inhaled in sufficient amounts. However, the lung-tissue reaction caused by inhalation of nuisance dusts has certain characteristics: (1) the architecture of the air spaces remains intact, (2) significant amounts of collagen (scar tissue) do not form, and (3) the tissue reaction is potentially reversible.[5] Excessive concentrations of nuisance dusts 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 irritation. The ACGIH TLV for nuisance dusts was established to prevent irritation.

2. Aluminum Oxide

Aluminum oxide or alumina is also classified as a nuisance dust. At the present time there are no clinical studies implicating aluminum oxide as a cause of pneumoconiosis (dust retained in the lungs). The effects on the human body caused by the inhalation of aluminum dust and fumes are not known with certainty. Some of the findings currently reported in the literature suggest that pneumoconiosis might be possible. However, in the majority of the cases investigated, it was found that exposure was not to aluminum dust alone.[6] At one time aluminum powder was used for the treatment of silicosis patients. Although this treatment has since proven to be ineffective, the exposure data has been used as a guide in establishing the ACGIH TLV for aluminum oxide. According to this data, the daily inhalation of aluminum at sufficient concentration to result in the retention of 20 mg of aluminum in the lungs per day had not caused any lung damage.[3] The production of the pulmonary disease (e.g. Shaver's disease) from aluminum oxide fume inhaled concurrently with silica fumes is still not fully understood.[5]

3. Crystalline Silica

The crystalline form of silica, silicon dioxide, is widely distributed in nature and constitutes a major portion of most rocks, soils, and sand. Much of the silica of naturally occuring rocks (i.e. bauxite, clay) is in the combined form, bound chemically with other mineral oxides. Free crystalline silica, such as quartz, cristobalite, and tridymite, is silica which is not combined with any other element or compound.[7] The crystalline forms of silica can cause severe lung damage when inhaled. Silicosis is a form of pulmonary fibrosis caused by the deposition of fine particles of crystalline silica in the lungs. Symptoms usually develop insidiously, with cough, shortness of breath, chest pain, weakness, wheezing, and non-specific chest illnesses. Silicosis usually occurs after years of exposure, but may appear in a shorter time if exposures are very high. This latter form is referred to as rapidly-developing silicosis. Silicosis is usually diagnosed through chest X-rays, occupational exposure histories, and pulmonary function tests. The manner in which silica affects pulmonary tissue is not fully understood, and theories have been proposed based on the physical shape of the crystals, their solubility, toxicity to macrophages in the lungs, or their crystalline structure. There is evidence that cristobalite and tridymite, which have a different crystalline form from that of quartz, have a greater capacity than quartz to produce silicosis.[8]

C. Medical Criteria

Pulmonary function testing is normally used to detect two types of abnormalities - obstructive and restrictive. Obstructive lung disease ($FEV_1$ less than 80% of predicted or $FEV_1/FVC$ less than 70%) is due to abnormalities in the airways as measured by a decreased ability to exhale air from the lungs as rapidly as normal. This may be caused by asthma, cigarette smoking, and respiratory exposure to irritant chemicals or substances. Restrictive lung disease (FVC less than 80%) is detected by a decreased volume of air in the lungs and is usually due to scarring of the lungs as may occur with the lung fibrosis due to silicosis or asbestos exposure.

VI. RESULTS

A. Environmental

Of the 6 personal samples collected at the Fairfield Plant for respirable free silica, only one, the Screen Tender, was exposed above the NIOSH recommended limit (50ug/$M^3$) and above the OSHA standard (the permissible exposure limit or PEL). Respirable free silica exposures ranged from 4.2 ug/$M^3$ to 91 ug/$M^3$. Respirable dust exposures ranged from 0.04 mg/$M^3$ to 0.87 mg/$M^3$. The quartz content of the respirable airborne dust to which the Screen Tender was exposed was 9.1%. The quartz content could not be determined by X-ray diffraction in the other 5 personal samples because the amount of respirable dust collected was either too low or contained interfering aluminum compounds. The percent quartz in total airborne dust (non-respirable) ranged from 3.7% to less than 12.4%. The only raw material found to contain free silica (9.1% quartz) was M & D Ball Clay. A ledge dust sample taken above the Richardson mixer was mostly clay and contained 8.6% quartz. Results from a personal sample taken from a sizing and grinding machine operator contained much higher than expected amounts of respirable dust and sample tampering or contamination was suspected. Dust from fired brick materials contained from 1.7% - 3.6% free silica as cristobalite. Sampling results for respirable dust exposures monitored at the Fairfield Plant are presented in Table 1, page 1.

Of the 11 personal samples collected at the Bessemer Plant for respirable dust, 4 were considered as representative of excessive exposure. Respirable dust levels ranged from 0.1 to 9 mg/$M^3$. The highest exposures monitored were for the sacking of refractory castibles during the second shift. The lowest levels were for the brick sizing and grinding operation. The quartz content could not be accurately determined by X-ray diffraction in the personal samples because the amount of respirable dust collected was either too low or contained interfering aluminum compounds. A worker cleaning out a bucket elevator was exposed to 2.7 mg/$M^3$ respirable dust containing 2.7% free silica as cristobalite (based on bulk sample analysis). Based on the mineral dust formula for dust containing 2.7% cristobalite (see Section V) the permissible exposure limit for this dust is 1.1 mg/$M^3$. The Larry Car Operator was exposed to 3.33 mg/$M^3$ respirable dust. Although the silica content in this dust sample could not be accurately determined, the exposure is considered excessive and representative of a potential health hazard. Exposures above 3 mg/$M^3$ would exceed the OSHA PEL for respirable dust containing only 1.3% quartz. Because of aluminum compound interferences, X-ray diffraction analysis of the respirable dust bulk air sample collected in the larry car area could not quantitate a quartz content below 4.3%. The percent quartz in bulk air dust samples for total dust (non-respirable) ranged from less than 1% to less than 6%. The only raw material found to contain free silica (9.2% quartz) was M & D Ball Clay. Dust from fired brick materials contained 2.7% free silica as cristobalite. Sampling results for respirable dust exposures monitored at the Bessemer Plant are presented in Table 1, page 2 and 3.

The results from the samples collected for total or non-respirable dust and aluminum oxide are presented in Table 2. Total dust exposures ranged from 1.47 mg/$M^3$ to 50.63 mg/$M^3$ at the Bessemer Plant and from 0.22 mg/$M^3$ to 2.92 mg/$M^3$ at the Fairfield Plant. Aluminum oxide levels ranged from 0.1mg/$M^3$ to 7.9 mg/$M^3$ at the Bessemer Plant and from 0.1 to 0.7 mg/$M^3$ at the Fairfield Plant. None of the 7 samples taken at the Fairfield Plant exceeded the evaluation criteria for nuisance dusts or aluminum oxide (10mg/M3). Five out of 11 samples from the Bessemer Plant were above the evaluation criteria. However, one of these jobs, the cleaning of a bucket elevator, was not representative of a daily exposure. The other jobs exceeding the criteria were performed daily and workers performing these jobs are required to wear NISOH approved cartridge mask respiratory protection or NIOSH approved disposable dust masks. Local exhaust systems were operating at the time of the survey but some of the systems needed repair to prevent dust leakage.

B. Employee Interview Results

Interviews with approximately fifteen current employees revealed a variety of health complaints including upper respiratory irritation, frequent productive cough, and wheezing. Several retired workers indicated problems with respiratory disease although exact diagnosis could not be determined.

C. Medical

Comparison of the personnel lists with the list of workers having chest X-rays and pulmonary function testing revealed good participation in the screening program (approximately 85%).

Review of the pulmonary function data revealed problems with the interpretation of results. In several instances, the best of the three trials was not used, leading to overdiagnosis of possible lung disease based on the pulmonary function test results. However, there were no instances of under-interpretation of the test findings, and in most instances the discrepancies were minor.

Of the 86 Bessemer workers screened, 9.3% had obstructive findings on pulmonary function testing, 4.7% restrictive, and 2.3% mixed obstructive-restrictive. Of the 898 Fairfield plant workers, 10.2% had obstructive, 12.5% restrictive, and 3.4% mixed obstructive-restrictive findings. All of the workers with obstructive lung findings were reported to be cigarette smokers. Nearly all of the workers with restrictive findings had tracing results which indicated that the abnormalities were due to poor effort on the test, rather than clinical illness.

Review of the X-ray findings for possible silicosis was difficult due to the predominant use of 70mm screening X-rays, rather than standard clinical X-rays. Fifteen chest X-rays from workers thought to be at the highest risk for pneumoconiosis (based on seniority at the plant or restrictive findings on pulmonary function) were reviewed, and none were found to have any indication of pneumoconiosis. Review of the Industrial Health Council files on these workers and on several other Harbison-Walker workers with abnormal screening X-rays revealed all abnormalities to be unrelated to occupational exposures.

## VII. DISCUSSION AND CONCLUSIONS

### A. Environmental

As observed by the NIOSH investigators during the first follow-up survey in August, 1980, the packaging of refractory castables was a very dusty job, especially for the worker dumping 50 pound bags of calcine aluminate cement (Alcoa CA-25). His personal exposure to an airborne concentration was over 50 mg/$M^3$. CA-25 is mostly aluminum oxide but does contain about 18% lime (calcium oxide) and would likely be very irritating to the eyes and skin. Both workers were wearing disposable dust masks but no eye protection. NIOSH investigators noticed a large amount of dust blowing from a broken dust collector duct near the dry pan above the floor where refractory castables were being packaged. The broken duct was identified to H-W supervisory personnel. The production supervisor said this duct, which was no longer used, would be removed and the hole sealed as soon as possible. During the NIOSH follow-up survey in November, 1980 this leak had still not been repaired. When this fact was again brought to the attention of H-W management personnel, the leak was repaired that day.

Machinists at the Fairfield Plant were very upset about the dust fallout from the main plant which had been reported to "fall like snow" on the driveway outside their shop. They believed this to be caused by dust discharged from the dryer stack. No dust was observed coming from the stack during the initial survey and the dryer was not operating during our follow-up survey. However, dust fallout was evident the afternoon of August 6th. The source of the dust was traced to the one of the bulk storage silos which had built up pressure and was venting dust over the unloading dock. The problem was corrected by the Screen Tender and the dust discharged stopped. How frequently this problem occurs was not determined. A NIOSH X-ray diffraction analysis did not detect free silica in a bulk sample of this dust collected the day of the fallout.

The local exhaust system on both the brick sizing and grinding machines were found to effectively control dust exposures at both the Fairfield and Bessemer Plants. Several of the workers at the Bessemer Plant mentioned that prior to the NIOSH follow-up survey, H-W maintenance personnel had removed a plastic bag from an exhaust duct and that since that time dust levels had been greatly reduced during sizing and grinding. Workers believed the blocked duct may have gone undetected for quite some time.

### B. Medical

Review of the medical testing on Harbison-Walker employees revealed no evidence of pneumoconiosis in these workers. Although chest X-rays were not available for all workers due to a medical screening program not designed for detecting early pneumoconiosis, clinical chest X-rays were available on a number of workers thought to be at highest risk for pneumoconiosis due to their seniority at the plants. Review of the available X-rays on this higher risk group found no evidence of pneumoconiosis. As clay containing significant amounts of free silica is currently used at the plant, the absence of X-ray findings compatible with silicosis should not be interpreted as a reason not to fully control silica exposures nor not to provide screening for possible pneumoconiosis.

The high prevalence of obstructive lung findings in the pulmonary function testing done at the plant is difficult to interpret. While cigarette smoking probably is a major cause of these findings, occupational exposures to irritant dusts may also contribute. The initial interviews at the plant found a high prevalence of respiratory irritation even in non-smokers, and efforts to control dust exposures should be continued.

## VIII. RECOMMENDATIONS

1. Management at the Bessemer Plant should give higher priority to inspection, maintenance, and repair of dust control systems. Workers who suspect a system is not working properly should report the condition to their supervisor who should follow-up to insure the system is repaired promptly. The leaking exhaust system found by NIOSH in the dry pan and refractory castibles area and the blocked duct found on the exhaust system for the brick grinding and sizing machine are prime examples of misplaced priorities for maintenance activities. That dust control systems do not affect production is no reason to delay needed repairs.

2. Bessemer Plant employees working on the M & D unloading dock complained that the door seal for the rail hopper cars will not prevent the very fine powdered M & D Ball Clay from escaping into their work area. Although this is an outside area, workers must stand near the rail car while it is being unloaded into the "pod" which pumps the material into a storage silo. This dust contains approximately 10% respirable free silica as determined by the NIOSH analysis of the clay bulk sample. Workers should make every effort to insure as good a fit as possible on the door seal before loading the silo. Damaged seals should not be used. NIOSH approved respirators designed to protect against dusts containing free silica should be worn during unloading. Clothes should be vacuumed off (while wearing respirators) before returning to the plant or before starting other jobs on the dock.

3. The oil which coats the freshly formed bricks carried from the brick press by the Press Operators is 95% No. 2 diesel oil and 5% animal fat. Some press operators had experienced oil folliculitis on their forearms, an oil acne which is caused by insoluble oil collecting within the hair follicle opening,

irritating that area sufficiently to cause an inflamation of the hair follicle. Use of barrier cream, and conscientious personal hygiene by the operators should help to control this problem.

4. The medical screening program at the plants needs to be better coordinated to insure adequate follow-up of workers found to have abnormalities and to allow prospective review of screening results. The current efforts to improve this program should be continued. The use of 70mm screening chest X-rays is not adequate for the early detection of pneumoconiosis. The use of standard clinical chest X-rays interpreted using the ILO-UICO classification system by a physician trained in this system of interpretation would provide a better method for the detection of early silicosis. These chest X-rays would not have to be done annually, but rather on a more intermittent basis with increasing frequency (yearly) in workers with greater seniority.

## IX. AUTHORSHIP AND ACKNOWLEDGEMENTS

| | |
|---|---|
| Evaluation Conducted and Report Prepared By: | Stanley A. Salisbury, CIH<br>Principal Environmental Investigator<br>NIOSH Region IV<br>Atlanta, Georgia |
| | James M. Melius, M.D.<br>Chief, HETAB,<br>Division of Surveillance, Hazard Evaluations, and Field Studies<br>NIOSH<br>Cincinnati, Ohio |
| Environmental Assistance: | Leigh Greeley<br>NIOSH Region IV<br>Atlanta, Georgia |
| Originating Office: | Hazard Evaluations and Technical Assistance Branch<br>Division of Surveillance, Hazard Evaluations, and Field Studies<br>NIOSH<br>Cincinnati, Ohio |
| Laboratory Analyses: | Staff<br>Measurements Research Support Branch, NIOSH<br>Cincinnati, Ohio |

## X. DISTRIBUTION AND AVAILABILITY

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 ninety (90) days the report will be available through the National Technical Information Service (NTIS), Springfield, Virginia 22161. Information regarding its availability through NTIS can be obtained from the NIOSH Publications Office at the Cincinnati, Ohio address.
Copies of this report have been sent to:

1. Harbison-Walker Refractories:
   - Corporate Safety Director
   - Personnel Manager, Fairfeild and Bessemer Plant Operations
2. United Steelworkers of America:
   - International
   - Sub-District Director, District 36
   - President, Local 531
   - President, Local 553
3. U.S. Department of Labor, OSHA, Region IV
4. NIOSH, Region IV
5. Designated State Agencies

For the purpose of informing the approximately 65 "affected employees", the employer will promptly "post" this report for a period of thirty (30) calendar days in a prominent place(s) near where the affected employees work.

## XI. REFERENCES


1. "Threshold Limit Values for Chemical Substances and Physical Agents in the Workroom Environment with Intended Changes for 1981", American Conference of Governmental Industrial Hygienists (ACGIH), Cincinnati, Ohio.

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5. Documentation of the Threshold Limit Values, American Conference of Industrial Hygienists (ACGIH) 4th. Edition, with Supplemental Documentation for 1981, Cincinnati, Ohio: ACGIH; 1980.

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8. Criteria for a Recommended Standard, Occupational Exposure to Crystalline Silica. DHEW (NIOSH) Publication No. 75-120, Cincinnati, Ohio: NIOSH; 1974.

RESULTS OF SAMPLING FOR RESPIRABLE SILICA DUST
BESSEMER PLANT
August 7, 1980

| Job/Area | Sampling time | Sample volume (liters) | Conct. of dust mg/M3 | Percent[1] quartz | PEL[3] mg/M3 | Percent[2] cristobalite | PEL[4] mg/M3 | Resp. free[5] silica ug/M3 |
|---|---|---|---|---|---|---|---|---|
| Hi-vol sample (total dust): | | | | | | | | |
| - Shuttle conveyer area | 11:45am-3:04pm | 633.6 | -- | <6.0 | -- | <1.2 | -- | |
| Personal samples: | | | | | | | | |
| - Outside loading conveyer | 8:09am-2:38pm | 661.3 | 0.54 | <6.0 | >1.25 | <1.2 | >1.56 | <32 |
| - Raw materials handler | 8:14am-2:25pm | 647.7 | [1.99] | <6.0 | >1.25 | <1.2 | >1.56 | <32 |
| Ground bats: | | | | | | | | |
| - High duty fire clay | (bulk sample) | -- | -- | ND | -- | 2.7 | -- | |
| Personal samples: | | | | | | | | |
| - Cleaning bucket elevator | 8:17am-2:42pm | 652.8 | [2.7] | -- | -- | 2.7 | 1.1 | |
| - Front end loader oper. | 8:25am-2:29pm | 600.6 | 0.6 | -- | -- | 2.7 | 1.1 | |
| Hi-vol sample (resp. dust): | | | | | | | | |
| - Larry car area | 9:13am-2:56pm | 3087 | -- | <4.3 | -- | <1.0 | -- | |
| Personal samples: | | | | | | | | |
| - Larry car operator | 8:29am-2:54pm | 654.5 | [3.33] | <4.3 | >1.6 | <1.0 | >2.5 | <143 |
| - Mixer/Pug mill opr. | 8:39am-3:01pm | 649.4 | 0.68 | <4.3 | >1.6 | <1.0 | >2.5 | <29 |
| Hi-vol sample (total dust): | | | | | | | | |
| - Dry pan area | 8:58am-2:57pm | 1292.4 | -- | <1.3 | -- | ND | -- | |
| Personal samples: | | | | | | | | |
| - Dry pan operator | 8:35am-3:04pm | 661.3 | 3.02 | <1.3 | >3.0 | ND | -- | <39 |
| Refractory castable dust | (bulk sample) | -- | -- | ND | -- | ND | -- | |
| Calcine aluminate dust | (bulk sample) | -- | -- | ND | -- | ND | -- | |
| Hi-vol sample (total dust): | | | | | | | | |
| - Castable sacking area | 3:53pm-5:28pm | 1017 | -- | <2.8 | -- | <0.6 | -- | |
| Personal samples: | | | | | | | | |
| - Sacking castables | 3:38pm-5:28pm | 176 | [2.78] | <2.8 | >2.1 | <0.6 | >1.9 | <77 |
| - Cracking sacks (calcine aluminate) | 3:38pm-5:28pm | 181.5 | [9.04] | -- | 5.0 | -- | 5.0 | |
| UCAL 70-6 | (bulk sample) | -- | -- | ND | -- | ND | -- | |
| M and D ball clay | (bulk sample) | -- | -- | 9.2 | -- | ND | -- | |

Evaluation Criteria:
NIOSH Recommended limit for respirable free silica = 50 ug/M3
OSH tandard or PEL - see (3) and (4) on Table 1, page

TABLE 1 (Page 1 of 3)
HARBISON-WALKER REFRACTORIES
HE 80-86

RESULTS OF SAMPLING FOR RESPIRABLE SILICA DUST
FAIRFIELD PLANT

August 6, 1980

| Job/Area | Sampling time | Sample volume (liters) | Conct. of dust mg/M3 | Percent(1) quartz | PEL(3) mg/M3 | Percent(2) cristobalite | PEL(4) mg/M3 | Resp. free(5) silica ug/M3 |
|---|---|---|---|---|---|---|---|---|
| Ledge dust on Rich. mixer | (bulk sample) | -- | -- | 8.6 | -- | -- | -- | |
| Hi-vol sample (total dust): | | | | | | | | |
| - above Richardson mixer | 9:00am-3:25pm | 1309 | -- | 12.4 | -- | <1.5 | -- | |
| Personal samples: | | | | | | | | |
| - Screen tender | 7:41am-2:49pm | 727.6 | [0.87] | 10.5 | 0.8 | -- | -- | [91.0] |
| - Tram rail operator | 8:17am-2:52pm | 671.5 | 0.04 | 10.5 | 0.8 | -- | -- | 4.2 |
| UFALA ground bats | (bulk sample) | -- | -- | ND | -- | -- | -- | |
| Hi-vol sample (total dust): | | | | | | | | |
| - on hopper in unload area | 8:02am-3:00pm | 1442 | -- | <3.7 | -- | 1.7 | -- | |
| Personal samples: | | | | | | | | |
| - Raw materials man | 7:49am-2:58pm | 727.3 | 0.36 | <3.7 | >1.8 | 2.7 | 1.1 | 9.7 |
| - " " " | 7:53am-2:58pm | 722.5 | 0.19 | <3.7 | >1.8 | 2.7 | 1.1 | 5.1 |
| Sizing and grinding dust | (bulk sample) | -- | -- | ND | -- | 3.6 | -- | |
| Personal samples: | | | | | | | | |
| - Size and grind, feed in | 1:19pm-3:17pm | 192.3 | 0.78 | -- | -- | 3.6 | 0.9 | 28 |
| - Size and grind, feed out | 1:22pm-3:17pm | 184 | 3.97(6) | -- | -- | 3.6 | 0.9 | [143.0](6) |
| Kolex D-6 | (bulk sample) | -- | -- | ND | -- | ND | -- | |
| M and D ball clay | (bulk sample) | -- | -- | 9.1 | -- | ND | -- | |
| UCAL 60 boxite | (bulk sample) | -- | -- | ND | -- | ND | -- | |

Evaluation Criteria:
NIOSH Recommended limit for respirable free silica = 50 ug/M3
OSHA Standard or PEL - see (3) and (4) on Table 1, page 3

TABLE 1 (Page 3 of 3)

RESULTS OF SAMPLING FOR RESPIRABLE SILICA DUST
BESSEMER PLANT
BRICK GRINDING AND SIZING OPERATION

November 6, 1980

| Job/Area | Sampling time | Sample volume (liters) | Conct. of dust mg/M3 | Percent(1) quartz | PEL(3) mg/M3 | Percent(2) cristobalite | PEL(4) mg/M3 | Resp. free(7) silica ug/M3 |
|---|---|---|---|---|---|---|---|---|
| Hi-vol sample (total dust): | | | | | | | | |
| - exit end of grinder | 7:38am-3:05pm | 4023 | 1.6 | <2.5 | -- | <1.5 | -- | |
| Personal samples: | | | | | | | | |
| - Size and grind, feed in | 7:25am-3:13pm | 795.6 | 0.1 | <2.5 | >2.2 | <1.5 | >1.4 | <4.0 |
| - Size and grind, feed out | 7:22am-3:21pm | 862.2 | 0.3 | 2.5 | >2.2 | <1.5 | >1.4 | <10.2 |

Evaluation Criteria:
NIOSH Recommended limit for respirable free silica = 50 ug/M3
OSHA Standard or PEL - see (3) and (4)

(1) average of percent quartz in high volume and/or bulk sample collected in area
(2) average of percent cristobalite in high volume and/or bulk sample collected in area

(3) obtained from equation: $$\frac{10\ mg/M^3}{\%\ \text{respirable quartz} + 2}$$

(4) One half the value obtained from the above equation based on the percent cristobalite
(5) based on average of percent quartz or cristobalite in sample

(6) Sample tampering or unknown contamination suspected.
Results reported are probably higher than actual concentration.
(7) based on average of percent quartz and cristobalite in sample

$mg/M^3$ = milligrams per cubic meter of air
$ug/M^3$ = micrograms per cubic meter of air

[ ] - indicates sample results exceeds evaluation criteria

TABLE 2
HARBISON-WALKER REFRACTORIES
HE 80-86

RESULTS OF SAMPLING FOR TOTAL DUST AND ALUMINUM

FAIRFIELD PLANT, August 6, 1980

| Job/Area | Type Sample | Sampling Time | Sample Volume (liters) | Conct. of Dust ($mg/M^3$) | Aluminum ($mg/M^3$) | Aluminum Oxide as $Al_2O_3$ ($mg/M^3$) |
|---|---|---|---|---|---|---|
| Screen tender (no unloading) | personal | 7:41am-2:49pm | 684.8 | 2.92 | 0.19 | 0.7 |
| Tram rail operator | personal | 8:17am-2:52pm | 671.5 | 1.09 | 0.03 | 0.1 |
| Unloading dock, near crusher | area | 8:02am-2:59pm | 742.3 | 0.22 | ND | |
| Raw materials man (UCAL 60) | personal | 7:49am-2:58pm | 722.5 | 0.58 | ND | |
| Raw materials man (UCAL 60) | personal | 7:49am-2:58pm | 727.3 | 1.95 | 0.07 | 0.3 |
| Size and grind, feed in | personal | 1:19pm-3:17pm | 188.8 | 1.69 | ND | |
| Size and grind, feed out | personal | 1:22pm-3:17pm | 195.5 | 2.05 | 0.09 | 0.3 |
| **BESSEMER PLANT, August 7, 1980** | | | | | | |
| Outside loading conveyer | personal | 8:09am-2:38pm | 661.3 | 1.47 | 0.05 | 0.3 |
| Raw materials handler | personal | 8:14am-2:35pm | 647.7 | 6.48 | 0.09 | 0.3 |
| Cleaning bucket elevator | personal | 8:18am-2:42pm | 652.8 | [27.04] | 0.95 | 3.5 |
| Front end loader operator | personal | 8:25am-2:29pm | 582.4 | 1.15 | 0.06 | 0.2 |
| Larry car operator | personal | 8:29am-2:54pm | 616 | [16.49] | 0.54 | 2.0 |
| Mixer/pug mill operator | personal | 8:39am-3:01pm | 622.7 | 2.44 | 0.12 | 0.4 |
| Dry pan operator | personal | 8:35am-3:04pm | 661.3 | [16.38] | 0.64 | 2.4 |
| Sacking castables | personal | 3:38pm-5:28pm | 187 | [10.86] | 0.86 | 3.2 |
| Cracking sacks (calcine aluminate) | personal | 3:38pm-5:28pm | 181.5 | [50.63] | 2.14 | 7.9 |
| **BESSEMER PLANT, November 6, 1980** | | | | | | |
| Size and grind, feed in | personal | 7:25am-3:18pm | 856.8 | 2.0 | 0.04 | 0.1 |
| Size and grind, feed out | personal | 7:22am-3:18pm | 705.4 | 1.6 | 0.03 | 0.1 |
| Evaluation Criteria: (ACGIH TLV for nuisance dust, aluminum, and aluminum oxide) | | | | 10 | 10 | 10 |

$mg/M^3$ = milligrams per cubic meter of air

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