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. 76-1-388

BOHN ALUMINUM AND BRASS CORPORATION
DANVILLE, ILLINOIS

APRIL 1977

I. TOXICITY DETERMINATION

Environmental investigations were conducted at Bohn Aluminum and Brass Corporation in February, May, and July of 1976. Medical examinations and tests were additionally done during the May and July surveys. The purpose of these investigations was to determine whether employees were exposed to toxic concentrations of Mac Stamp 68, a tooling lubricant, or brazing fumes. On the basis of environmental and medical data collected during these surveys, observations of work practices, and available literature relevant to the toxicity of substances used in the work areas, it has been determined that exposures of brazers to cadmium fumes are potentially toxic at concentrations measured during this investigation. Although exposures are only sporadic, the fact that cadmium tends to accumulate in the body over a number of years and that the long term effects of this accumulation are not well understood make it advisable to limit exposures to cadmium as much as possible.

Exposure to fumes of copper, zinc, and silver have been determined to be non-toxic at concentrations measured during this investigation.

It is further believed that exposures to Mac Stamp 68 will not produce any long term health effects. Vapors of this solvent may produce transient irritation of the eyes, nose, and throat, however, any direct skin contact could dry and defat the skin.

Concentrations of 1,1,1-trichloroethane and of fluorides have been determined to be non-toxic at the concentrations measured.

Recommendations to control or minimize existing hazards are offered herein.

II. DISTRIBUTION AND AVAILABILITY OF DETERMINATION REPORT

Copies of this Determination Report are 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 National Technical Information Service (NTIS), Springfield, Virginia, Information regarding its availability through NTIS can be obtained from NIOSH, Publications Office at the Cincinnati address. Copies have been sent to:

a) Bohn Aluminum and Brass Corporation
b) Authorized Representatives of UAW, Local 1271, Danville, Illinois
c) U.S. Department of Labor - Region V
d) NIOSH - Region V

For the purpose of informing the approximately 60 affected employees, the Determination Report shall be posted for a period of 30 calendar days in a prominent place(s) near where exposed persons 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.

In the early part of 1976, NIOSH was asked by the local union to investigate a problem at Bohn Aluminum and Brass Company, Danville, Illinois. A number of workers were alleged to have upper respiratory irritation, skin rashes, and breathing difficulties presumably due to cutting oil exposure. A NIOSH industrial hygiene team visited the plant in February, 1976. A combined industrial hygiene-medical team returned to the plant in May, 1976. The findings elicited during these two visits indicated potential excessive exposure to cadmium fume in addition to a potential problem with the cutting oil and prompted a further indepth study. This investigation was performed in late July and was directed toward discovering any adverse effects in the workers as a result of prolonged exposure to cadmium fume. The report to follow is a detailed description of the investigation that took place.

IV. HEALTH HAZARD EVALUATION

A. Process Description

Bohn Aluminum and Brass Corporation, Heat Transfer Division, manufactures finned heating and cooling coils both for the trade, to be used in commercial, industrial, or institutional heating and air conditioning units, or for use in Bohn's own air conditioning and refrigeration products. At the Danville facility, which has been in operation since 1956, approximately 400 people are employed in the production of these coils. There are about 260,000 square feet of manufacturing space and about 40,000 square feet of offices in which 300 administrative personnel are employed.

The operations investigated were copper fabrication, fin-press, and brazing.

1. Copper Fabrication

Copper tubing of various lengths is received in Department 03 and is bent into hairpin shapes on one of two types of machines. In one process, large rolls of copper tubing are unwound and threaded into the "automatic bender," cut to the appropriate length and bent into a hairpin shape. The Mac Stamp 68 is a tooling lubricant, primarily an aliphatic solvent with a small percent of chlorinated aliphatic solvent (the exact composition is considered proprietary). This is injected as a vapor onto the copper tubing and the machine parts. Several of these units may be operating at any given time, with one employee operating each of the machines. There is also a "hand bending" operation in which pre-cut and pre-lubricated lengths of copper tubing are placed, one at a time, into a machine which bends them into the hairpin shape. Exposure to Mac Stamp 68 in Department 03 would be from inhalation of the solvent vapors and from skin contact during the actual handling of the parts coated with the oil. There are 13 persons employed in Department 03 on the first shift and four persons on the second shift; there is no graveyard shift at Bohn.

2. Fin-Press

The fin-press in Department 12 is a punch press operation. Rolls of aluminum sheeting are uncoiled into the punch press, and simultaneously holes are punched for the copper tubing to fit through and the fins are cut to the appropriate size. These are then stacked and the fin-press operator fits the copper hairpin parts through the holes in the stick of fins. The fin spacing ranges from 4 to 24 fins per inch, with the exact dimension determined by the height of the fin collar. This is a continuous process, generating thousands of fins per hour. The operator is potentially exposed to Mac Stamp 68 since the aluminum is dipped into the lubricant before it is punched, and the Mac Stamp 68 is also sprayed into the die as the aluminum goes through.

3. Brazing

To complete the heating and cooling coils, "return bends," "caps," "leads," or other connections are brazed onto the copper tubing. For brazing copper to copper, an alloy of copper and phosphorous (93% : 7%) or silver, copper, and phosphorous (5% : 89% : 6%) is used. For brazing copper to brass connections, a brazing alloy of 35% silver, 36% copper, 21% zinc, and 18% cadmium or an alloy of 45% silver, 15% copper, 16% zinc, and 24% cadmium would be used. The brazing alloys are usually referred to in terms of their percent silver.

Whenever the alloys containing 35% silver or 45% silver are used, a brazing flux is spread on the surfaces to be brazed using a small brush. This flux contains fluorides.

In Departments 20s and 20f, a coil with a U-bend on the bottom is brazed to another coil to form a complete circuit. This usually involves copper to copper brazing, although certain orders require copper to brass brazing. Twenty-five persons worked in each of the two departments, which operate only during first shift.

In Department 01, headers or distributors are built, and both copper to copper and copper to brass brazing is done. About 30 persons work in this Department, however, no more than a dozen usually braze at any one time. There are also hand bending machines in this area at which employees may be exposed to Mac Stamp 68.

Copper to copper brazing is also done in Department 19 where very large coils are built. Coils are also tested for leakage in this area by immersing them in tanks of water and forcing compressed air through the circuit. If no leaks are found the coils are put on a large conveyor through a drying oven. Sixteen persons work in Department 19 on the first shift, 7 on the second shift, but there is no brazing done during second shift.

B. Evaluation Design and Methods (Environmental)

An initial environmental study was conducted on February 4-6, 1976, by NIOSH industrial hygienists for the purpose of evaluating employee exposure to Mac Stamp 68 and to fumes generated during brazing operations. Worker exposures to Mac Stamp 68 were monitored in Department 03, where copper tubing was bent, Department 12, the fin-press operation, and Department 19, where parts which had been machined with Mac Stamp 68 were being brazed. (Although the use of Mac Stamp 68 had been instituted because it does not require conventional degreasing in a solvent, a film of the lubricant often remains on the parts to be brazed.)

Charcoal tubes and Sipin pumps were used to collect personal breathing zone samples on employees in these three areas. Pumps were calibrated at 50 cc/minute and consecutive samples of approximately 10 liters each were taken over an 8-hour period.

Exposures to silver, cadmium, copper, zinc, and lead were investigated in Departments 20s, 20f, 01, and 19, during brazing operations. Personal sampling pumps drew air at a flow rate of 1.5 liters per minute through AA filters, contained in closed faced cassettes, to collect breathing zone samples on brazers.

During this initial visit to Bohn, 29 employees were interviewed using non-directed medical questionnaires to determine if there were any adverse health effects attributable to their exposures to substances used in the workplace.

Based upon information and data collected during the initial survey, it was decided that a combined environmental and medical investigation should be conducted to determine the range and severity of health effects and to fully characterize exposures of brazers in Departments 01, 20s and 20f to cadmium contained in the brazing alloy and fluorides contained in the brazing flux.

On May 17-19, 1976, a NIOSH physician and industrial hygienist returned to Bohn Aluminum and Brass Corporation to conduct a follow-up investigation. Personal breathing zone samples were again collected for Mac Stamp 68 and for metal fumes in the areas visited on the initial survey. Exposures to Mac Stamp 68 were monitored on both first and second shifts in Department 03 using Sipin pumps and charcoal tubes. Metal fume exposures in Departments 01, 20s, and 20f were characterized by personal breathing zone samples collected on AA filters. Fluoride exposures were additionally monitored by collecting personal breathing zone and general area samples wherever the brazing flux was used. Personal sampling pumps set at one liter per minute, drew air through an AA pre-filter and 15 ml of sodium acetate solution contained in impingers.

Medical interviews and limited physical examinations were also conducted to evaluate 29 employees.

It was determined that more extensive medical investigations would be necessary in order to fully characterize the health status of brazers who had been exposed to cadmium for a number of years.

The workforce at Bohn appeared to be very stable, with the length of service of brazers ranging up to 25 years. Most of the brazers were women, many of whom had been (or are) brazing during childbearing years and it was felt that their exposures and health status should be investigated. A third and final medical/environmental survey was conducted on July 27-30, 1976. This was arranged during a period of high cadmium usage.

Environmental air samples were again obtained on this survey, to be analyzed for cadmium, silver, copper, zinc, and fluorides, using methods identical to those used on the previous survey. Heat stress measurements were made next to the automatic brazing unit on July 29.

C. Evaluation Design and Methods (Medical)

The total number of workers, exposed and controls, who participated in this study was 38. Vacations and illnesses limited the number of persons (exposed to cadmium fumes) that were available for selection. Therefore, all of those who were braziers (those who work directly with cadmium solder) at the time of the study were asked to participate. This group numbered 20. There were 12 females and 8 males. Their age range was 25-60 with a mean of 37.9. This group had worked as braziers from .25 years - 20.0 years, with a mean of 7.9 years. A control cohort was selected and matched as closely as possible for age, sex, and smoking history. The control cohort consisted of office personnel, factory workers physically removed from the areas of exposure and NIOSH volunteers. There were 18 in the control group; 8 females and 10 males. There age range was 23 to 53 with a mean of 36.3. The control group had little or no known previous exposure to cadmium.

A series of tests were performed on these cohorts. The tests that were done included:

1. Pulmonary Function Studies (FVC - Forced Vital Capacity, FEV_1 - Forced Expiratory Volume in one second, and MMEF - Maximum Mid-Expiratory Flow)
2. Blood Pressure Measurement
3. Complete Blood Count (Hemoglobin, Hematocrit, White Blood Cell Count, Differential)
4. Blood Urea Nitrogen
5. Serum Creatinine
6. Serum Alpha-1-antitrypsin
7. Urinalysis*
8. Urine Beta-2-microglobulin*
9. Blood Cadmium Level
10. Urine Cadmium Level*
11. Hair Cadmium Level
12. Urine Uric Acid Concentration*
13. Urine Creatinine Concentration*
14. Medical History
15. Physical Examination

*All urine evaluations were performed on spot urine samples.

The analysis of the multiple specimens taken was performed by Medical Diagnostic Services, Inc., in Cincinnati, Ohio and the NIOSH Contract Laboratory in Salt Lake City, Utah. Standard analytical techniques were used for the biomedical evaluations and Atomic Absorption Spectrophotometry was used in the cadmium determinations on blood, urine and hair.

In addition to the previously described testing, a series of animal experiments were conducted to determine the irritancy and sensitization potential of the cutting oil "Mac-Stamp." Both rabbits and guinea pigs had various concentrations of "Mac-Stamp" applied to intact or abraded skin and their responses to these applications recorded.

After reception, logging and tabulating the data, T tests were performed on each medical test variable. Analysis within the exposed (brazier group) relating to total number of years brazing was carried out using the SPSS "ANOVA" program. This analysis of variance consisted of using years brazing, smoking and sex as main effects and age as covariant.

C. Evaluation Criteria

1. Environmental Standards

Three types of standards have been selected for use as criteria in evaluating the exposures of employees to substances used at Bohn. NIOSH has developed and recommended standards which are designed to protect the health and safety of workers employed for up to a 10-hour workday, 40-hour week, over a working lifetime. The U.S. Department of Labor enforces standards for over 400 chemical substances (29 CFR 1910.1000, Tables G-1, G-2, and G-3). The third type of criteria, Threshold Limit Values (TLV's), represent airborne concentrations of substances under which it is believed "nearly all workers" may be exposed without adverse effect. These have been recommended by the American Conference of Governmental Industrial Hygienists. The following table presents those standards applicable to the substances evaluated during this survey.

Substance	Federal Standard	ACGIH TLV	NIOSH Recommendation
Cadmium fume	0.1 mg/M^3*	0.05 mg/M^3	.05 mg/M^3
1,1,1-Trichloroethane	350 PPM	350 PPM	350 PPM
Copper fume	0.1 mg/M^3	0.2 mg/M^3	
Fluorides	2.5 mg/M^3	2.5 mg/M^3	2.5 mg/M^3
Silver	0.01 mg/M^3	0.01 mg/M^3	
Zinc (oxide fume)	5 mg/M^3	5 mg/M^3	5 mg/M^3
Heat Stress	See Toxicologic Effects Section		

*Acceptable ceiling concentration = 3.0 mg/M^3

There is no environmental standard for Mac Stamp 68. It is primarily an aliphatic solvent and would not be expected to be very volatile.

2. Toxicologic Effects

a) Metal Fumes

(1) Cadmium

Cadmium fumes are produced during brazing operations at Bohn in which the alloys containing 35 and 45 percent silver are used. Cadmium fume is a severe pulmonary irritant and in high concentrations over short periods of time can lead to pulmonary edema and death. Throat irritation, cough, chest pain, and dyspnea are common symptoms following acute exposure. In severe cases, acute pulmonary edema may develop within 24 hours of exposure, eventually followed by permanent lung damage in the form of fibrotic changes. Chronic exposure may lead to pulmonary

emphysema, renal tubular dysfunction (even renal failure), rhinitis, ulceration of the nasal septum, olfactory nerve damage, and anosmia. Continuous ingestion of cadmium may cause back pain, joint pain, unsteady gait, osteomalacia and even bone fractures.

In occupational situations chronic cadmium poisoning follows repeated exposures over a long period of time. Cadmium is readily absorbed via inhalation and retention of absorbed cadmium has been found to be very high. It tends to accumulate in the liver and kidneys as it is stored in the cadmium-binding protein, metallothionein. The biologic half life of cadmium in humans is unknown, however, based on mathematical models, it has been estimated to be as high as 10 to 30 years. Excretion is slow. Urinary concentrations of cadmium have no diagnostic significance in terms of severity or duration of exposure and indicates only increased absorption of cadmium.

As early as 1947, Hardy and Skinner[1] described 5 cases of chronic cadmium poisoning in a plant manufacturing cadmium faced bearings. Air concentrations ranging from 0.17 to 0.46 mg/cu m were reported, and the duration of exposure for the five men ranged from 4 to 8 years. Workers experienced varying degrees of symptomatology, including loss of appetite, nausea, vomiting, epigastric and sternal pain, constipation, fatigue, dental trouble, and burning of the throat. Hemoglobin levels were decreased in two and cadmium was found in the urine of all five (0.01-0.05 mg per liter).

Ventilatory function was assessed by Kazantzis[2] in workers exposed to cadmium in casting operations in two factories in Great Britan. Mean values for vital capacity and maximum ventilatory capacity were not found to be significantly different when control groups from the same factories were compared to the exposed groups. However, mean values for two other indices of pulmonary function were found to differ significantly, indicating possible ventilatory impairment. A follow-up on these 100 men, 5 years later, revealed a greater deterioration in performance of respiratory function tests in the exposed group as compared to the controls.[3] The authors also reported forty-three diagnosed cases of chronic cadmium poisoning, compared to 19 in the initial study. Emphysema and/or proteinuria were the primary findings in these workers. Results of atmospheric sampling at one of the factories showed a range of 10 to 80 ug Cd/cu m during the later survey and 5 to 270 ug/cu m on the prior study.

In a more recent study,[4] kidney damage, as evidenced by proteinuria, was reported to be more prevalent than pulmonary ventilatory impairment when 3 groups of workers exposed to cadmium were examined. Excessive proteinuria was found in 15% of men exposed to cadmium for less than 20 years and in 68% of men exposed for more than 20 years, to concentrations reported to be less than 200 ug/cu m. Proteinuria is believed to be indicative of tubular damage caused by the accumulation of cadmium in tubular epithelial cells,[5,6,7] and excretion of low molecular weight proteins, such as B_2 microglobulin, is one of the early signs of cadmium toxicity.

Increased destruction of red cells and bone marrow depression accompanied by mild to moderate hypochromic anemia have also been reported.[7,8]

Evidence from biochemical studies and from toxicologic experiments on animals indicates that zinc may prevent manifestations of cadmium toxicity.[9,10] Cadmium and zinc are believed to compete for the same binding sites and where zinc is bound preferentially to cadmium, the ability of cadmium to interfere with or inhibit normal biochemical activity is suppressed. Zinc appears to form more stable complexes when nitrogen or oxygen are the ligands but cadmium seems to bind more freely with sulfur groups.[9] In one experiment, rabbits treated with both cadmium and zinc were compared to rabbits treated with cadmium alone for 5 days per week for 6 months.[11] Moderate light chain proteinuria and slight tubular damage were found in those rabbits receiving doses of both metals, whereas rabbits treated with cadmium alone developed severe proteinuria and extensive tubular damage. In addition present animal data suggests cadmium to be a carcinogen as well as a teratogen. Increased incidence of prostatic and lung cancer have been reported in humans exposed to cadmium fume.[20]

(2) Zinc

Many metal fumes, including zinc, are capable of producing a syndrome referred to as "metal fume fever." This is characterized by symptoms including chills and fever, nausea, vomiting, dryness of the throat, coughing, fatigue, and weakness, sometimes accompanied by mental confusion and decreased pulmonary vital capacity. This condition is usually temporary.

In an experiment in which 2 persons voluntarily exposed themselves to zinc oxide vapors,[12] a sweetish taste was experienced as well as a tickling sensation in the nasal passages, coughing, nausea and anorexia, headache, malaise, chills, and fever. White blood cell counts on both men indicated a moderate leukocytosis which reached a peak about 30 hours following inhalation and which persisted even after the febrile reaction had subsided. Vital capacity was also found to be reduced in both men. The average concentration to which the subjects were exposed was 600 mg/cu m, and the lengths of exposure were 10-1/2 and 12 minutes.

(3) Copper

Copper fume is also capable of producing metal fume fever, and in some instances, a discoloration of the skin and hair. Exposures to copper fume have also been associated with congestion of the nasal mucous membranes, ulceration of the nasal septum, and sometimes pharyngeal congestion. Chronic exposure can lead to irritation of the respiratory tract, a metallic or sweet taste, nausea, and more seriously, damage to the liver, kidneys, or spleen.

(4) Silver

Silver can accumulate in body tissues and produce argyria, a blue-gray discoloration of the skin, mucous membranes, and eyes, but this appears to result only after prolonged and repeated exposures. Systemic effects have not been documented.

(5) Fluorides

Industrial exposures to fluorides have produced irritation of the eyes and respiratory tract, nosebleeds, nausea, "sinus troubles," and skin rashes. Repeated exposure to high concentrations may also produce osteosclerosis.

(6) Mac Stamp 68

There is no report in the literature relating to the industrial toxicity of Mac Stamp 68. Since it is primarily an aliphatic hydrocarbon, it might be expected to produce central nervous system depression if sufficient quantities are inhaled. Other possible health effects could include irritation of the mucous membranes of the eyes, nose, and upper respiratory tract. Direct skin contact with the liquid solvent may produce dehydration and defatting of the skin, causing irritation and possibly dermatitis.

(7) Heat Stress

Since measurement of deep body temperature is impractical for monitoring the workers heat load, the measurement of environmental factors is required which most nearly correlate with deep body temperature and other physiological responses to heat. At the present time wet bulb-globe temperature index (WBGT) is the simplest and most suitable technique to measure the environmental factors. WBGT values are calculated by the following equations:

1. Outdoors with solar load:

   WBGT = 0.7 WB + 0.2 GT + 0.1 DB

2. Indoors or outdoors with no solar load:

   WBGT = 0.7 WB + 0.3 GT

   WBGT = Wet bulb glove temperature index
   WB = Natural wet bulb temperature
   DB = Dry bulb temperature
   GT = Globe thermometer temperature

The determination of WBGT requires the use of a black globe thermometer, a natural wet blub thermometer, and a dry bulb thermometer.

(8) 1,1,1-Trichloroethane

Main effect of exposure is anesthesia. Increased concentrations can cause mild irritation of mucous membranes and disturbed equilibrium. May cause decreased blood pressure, transient elevations of transaminase levels and at extremely high levels death from suffocation.

D. Evaluation Results

1. Environmental

The results of analyses of environmental air samples collected at Bohn Aluminum and Brass Corporation are presented in Tables I, II, III, and IV.

During the initial survey, concentrations of Mac Stamp 68 were found to range up to 33 ppm with an average concentration of 6 ppm. The two highest concentrations (30 and 33) were measured on breathing zone samples from the operator of the #5 Automatic Bender in Department 02. Breathing zone concentrations at the fin-press were 13 and 12 in two consecutive samples, and concentrations of Mac Stamp to which brazers were exposed in Department 19 ranged from 2 to 4 ppm.

In May, Mac Stamp 68 concentrations ranged up to 55 ppm with an average concentration of 10 ppm. The highest concentration was measured in the breathing zone of the fin-press operator and the next highest concentrations (28 and 23 ppm) were measured on breathing zone samples from the #6 and #8 Automatic Benders. 1,1,1-trichloroethane concentrations were also monitored during this visit and concentrations of up to 17 ppm were measured, with an average level of 4 ppm. 1,1,1-trichloroethane was found on charcoal tube samples that had been collected in areas where only Mac Stamp 68 was used, probably indicating both a plant-wide environmental air contamination and also the presence of chlorinated hydrocarbons in Mac Stamp 68. Mac Stamp 68 was likewise found on samples from the degreasing areas, most likely as a result of environmental air contamination from nearby areas in which Mac Stamp 68 was used. Tables I and II presents the results of analyses for Mac Stamp and 1,1,1-trichloroethane.

Filter samples obtained in the breathing zones of brazers on February 5 and 6, 1976, were analyzed by atomic absorption spectroscopy for silver, cadmium, copper, zinc, and lead. No lead was detected on any of the filters, therefore samples obtained on subsequent surveys were not analyzed for this metal. Silver was only detected on 9 of the 62 filter samples taken during the three plant visits, and the highest concentration was 0.015 mg/M^3, measured in July on a breathing zone sample of a brazer in Department 20. The other silver concentrations ranged from 0.001 to 0.009 mg/M^3.

Copper concentrations ranged up to 0.089 mg/M^3 during brazing operations, with average concentrations of 0.026, 0.017, 0.006, and 0.013 mg/M^3 on February 5 and 6, May 17-19, July 28, and July 29, respectively.

The highest zinc concentration on any of the filter samples was 0.281 mg/M^3. This was measured in the breathing zone of a brazer in Department 20f during the use of the 35% silver alloy in February. Other environmental air concentrations averaged 0.033 mg/M^3 in February, 0.013 mg/M^3 in both May and on July 28, and 0.022 mg/M^3 on July 29.

The highest cadmium concentrations were measured in February, when they ranged from 0.005 to 0.366 mg/M^3. The average concentration was 0.074 mg/M^3 during that survey. The five highest values were all found in the breathing zones of brazers in Department 20f while they were using the 35% silver alloy. In May, very little cadmium-containing alloy was used and the average environmental air concentration measured during that part of the investigation was 0.001 mg/M^3, and 8 of the 17 filters had no detectable amounts of cadmium on them. In July, environmental air concentrations of cadmium averaged 0.015 mg/M^3 (with a range up to 0.049) on the 28th, and 0.033 mg/M^3 (ranging up to 0.185) on the 29th.

Environmental concentrations of fluorides were also monitored during May and July. Only two of the 8 samples collected in May had any detectable amounts of fluorides. These were both area samples collected next to brazers in Department 01, and each had 0.002 mg/M^3 of fluorides. In July, fluoride concentrations ranged up to 0.419 mg/M^3 with an average of 0.090 mg/M^3.

Heat stress measurements were also performed. The WBGT, an index used when evaluating worker exposure in hot environments was calculated for July 29. For indoor exposure, the following calculation is made:

WBGT = 0.7 WB + 0.3 GT

WB = Natural wet bulb temperature obtained with a wetted sensor exposed to the natural air movement.

GT = Globe thermometer temperature

The temperature measurements and results of calculations for WBGT are included in Table VI. All measurements were below the permissible heat exposure TLV for continuous light load (30.0 C) and moderate load (26.7 C) activity.

2. Medical Results and Discussion

Twenty workers exposed to cadmium fume (braziers) and 18 controls (those with little or no cadmium exposure were evaluated in this study. By history, 14 exposed workers (70%) and 10 controls (55%) were smokers. Their mean pack year consumption was 27.8 and 22.5 respectively.

*One pack year = one package of cigarettes per day for one year.

As seen in Table VII both groups were compared in how they responded to the medical questionnaire. Headache and chest tightness were the only two symptoms that occurred more frequently in exposed workers than control workers and were statistically significant ($p < .05$). These symptoms are frequently encountered in workers exposed to cadmium fume.

Physical examinations were performed on both cohorts. Blood pressure**, height, weight, skin examination, and evaluations of teeth, lungs, heart, and sense of smell were done. Table VIII shows the comparisons between the groups. No significant differences were found.

In addition to the history and physical examination, a number of biomedical tests were done. These are listed in Part IV, Section B. The results of the biomedical evaluations can be found in Tables IX through XX. These Tables show individual worker values as well as means and standard deviations. All of these biomedical evaluations were done as listed in Part IV, Section B. Pulmonary function studies were performed using the "Vitalograph" machines and predicted normal values for height, sex, and age taken from Kamburoff et al.[13]

Evaluation of Mac Stamp 68, a cutting oil in use at Bohn was studied to access its skin irritancy and sensitization properties. Guinea pigs were used to determine sensitization and rabbits were used to test irritancy potential. Table XX shows the results of the skin irritancy and sensitization testing indicating that Mac Stamp is irritating but probably not a sensitizing agent.

Careful analysis of the laboratory data revealed no significant differences ($p < .05$) between the control and exposed groups. Analysis of variance comparing those who worked greater than 10 years and those working less than 10 years, both males and females, in the brazing operations showed only one variable, urine creatinine, to be significantly different. The meaning of this is unknown.

Workers 3, 21, and 22 (See Tables X, XII, XIV, XVI, XVIII, XIX) deserve special consideration at this time. These workers were observed to have a variety of abnormalities in one or more of the biomedical evaluations performed in this hazard evaluation. The abnormalities in forced vital capacity (FVC), forced expiratory volume in one second (FEV_1) and FEV_1/FVC ratios were the most consistant in these three workers. Their values in these tests indicate moderate to severe pulmonary disease that was difficult to attribute to non-occupational causes.

All of these results must be considered with respect to a number of factors. First, the relationship between years worked as a brazier and actual exposure to cadmium fume can only be estimated because of the intermittant and irregular use of cadmium containing solders. It is possible that "years brazing" is an inappropriate measure of the true exposure. Second, the possibility that some of those who served as control may have at some time received significant exposures to cadmium unknown to them. Third, and perhaps the most important, is the recently reported protective effects of zinc.[14] During exposure to heavy metals such as cadmium or lead, zinc has been shown to have a protective effect. The workers at Bohn Aluminum and Brass did have exposures to zinc.

**Blood pressure greater than 140/90 was considered as normal.

F. Conclusions (Environmental)

It is believed that exposures of brazers to cadmium fume at Bohn Aluminum and Brass Corporation are potentially toxic under the conditions observed during this investigation. Recognizing that the use of cadmium containing brazing alloys may be only sporadic in nature, it is felt that since cadmium is not rapidly metabolized and excreted and therefore tends to accumulate in the body, even sporadic exposures at the concentrations measured may produce adverse health effects. Furthermore, the long term health effects of chronic exposure to cadmium are not fully understood and it is possible that irreversible systemic damage (kidney damage or pulmonary disease) may be occurring even before symptoms (proteinuria or reduction in ventilatory capacity) present themselves. The medical data does indicate that cadmium has been absorbed by the body in brazers and since there are no defined "safe" biological levels, it is recommended that employee exposures to cadmium be limited via administrative and environmental controls. This should be supplemented by a continuing program of medical surveillance of all workers exposed to cadmium in the work place.

Exposures to fumes of copper, zinc, and silver have been determined to be non-toxic at the concentrations measured during this evaluation. Breathing zone concentrations of these metals were below existing standards for occupational exposures. Additionally, medical findings did not indicate any health effects attributable to these exposures.

On the basis of environmental monitoring in Departments 03 and 12 and on physical examination of workers exposed to Mac Stamp 68, it is believed that exposures to vapors of Mac Stamp 68 may produce transient sensory irritation, especially of the upper respiratory tract, and direct contact could dry and defat the skin possibly resulting in dermatitis. Specific animal experiments conducted by NIOSH to test Mac Stamp 68 for irritation and sensitization potential showed that this solvent could cause irritation in sufficient concentrations, but no sensitization was produced in guinea pigs. Irritation of the skin could be avoided by the use of appropriate protective clothing, including impervious gloves and aprons. Alternatively, coveralls could be worn which would be removed before leaving the plant and laundered before reuse.

Concentrations of fluorides and of 1,1,1-trichloroethane as measured during this investigation have been determined to be non-toxic. Environmental concentrations were consistently low and medical findings did not reveal any symptoms indicative of over-exposure to either substance.

NIOSH has defined a "hot environmental condition" as any combination of air temperature, humidity, radiation, and wind speed that exceed a WBGT of 79°F. Although this level was not exceeded on July 29, certain provisions are advised to reduce the peaks of physiologic strain in order to insure the health of workers. These would include frequent work breaks to allow employees to get water and replacement salt, the use of appropriate protective clothing and equipment acclimitization of employees, and defined work-rest regimens.

G. Conclusions (Medical)

A variety of medical and biomedical evaluations were performed during this hazard evaluation. Comparison of the exposed and control cohorts revealed no significant differences in the biomedical test results. Physical examinations revealed no significant group differences. Comparison of symptomatology showed significant occurrence of headache and chest tightness in the exposed group over that in the control group.

The lack of significant differences between these groups is surprising considering the environmental measurements showing increased cadmium fume levels intermittently present in the brazing work areas. Several possible explanations for this are listed in the preceding section. It is this investigators opinion that a potentially toxic situation existed during this evaluation. It is apparent that certain individuals in the brazing group, workers #3, 21, and 22 may have been effected by cadmium fume exposure despite the fact that there were no statistical differences in the groups as a whole. The individuals mentioned had abnormal findings possibly related to cadmium exposure that could not easily be explained by other causative agents, i.e., heavy tobacco consumption.

V. RECOMMENDATIONS

Pursuant to the above conclusions, the following specific recommendations are made:

1. Ventilation Control:

In Department 01, employee exposure could be substantially reduced if the ventilation system were operating. Ventilation measurements done during July indicated that the presence of individual fans blowing air down toward the employees sitting at the bench totally compromised the attempt to move contaminant air into the exhaust hood and out of the work area. Assuming that the exhaust fan capacity is sufficient, cadmium and other metal fumes could be vented away from the breathing zones of the workers if the individual cooling fans were not working at cross-purposes to the hood.

In Departments 20s and 20f there was no local exhaust ventilation. Since high contaminant concentrations were measured in this area during this investigation, it is recommended that some sort of ventilation be installed. This could either be a canopy hood over a special work bench at which all cadmium brazing could be done or portable exhause ventilation in the form of a flexible exhaust duct which would draw fumes away from the workers' breathing zones.

Make-up air must be provided. Perhaps if this make-up air were sufficiently cooled in summer, it would preclude the necessity for the individual cooling fans which tend to make it difficult to exhaust air in any one direction.

2. Temporary Administrative Control of Exposures:

It was apparent that even during special orders in which cadmium-containing alloy had to be used, that only a small proportion of the total number of braziers in Departments 20s and 20f actually used this alloy. Therefore, it would be advisable, as a temporary measure only, to rotate braziers on these special coils such that no person would be exposed to cadmium containing fumes for much more than a two-hour period on any one day. This is only a temporary measure and does not supplant ventilation control.

3. Medical Surveillance:

The following recommendations are offered to insure worker safety and health.

A. If a reasonable substitute is available the cadmium contained solder should be discontinued.

B. Routine pre-employment medical examinations should be performed as well as periodic physical examinations depending on age and job classification. A suggested time table is every 2-3 years while a worker is less than 40 years of age, then on a yearly basis thereafter.

C. The examinations should consist of medical history, physical examinations and appropriate biomedical testing. A suggested biomedical profile would include:

1) Blood Pressure Measurement
2) Pulmonary Function Studies
3) Chest X-ray
4) Electrocardiogram
5) Complete Blood Count
6) Urinalysis
7) Serum Multiphasic Analysis-12 (if cadmium use is continued)
8) Urine for Cadmium (24 hour collection)
9) Urine for Beta-2-Microglobulin

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TABLE I
BREATHING ZONE CONCENTRATIONS OF MAC-STAMP 68

BOHN ALUMINUM & BRASS CORP.
FEBRUARY 5 & 6, 1976

DPET.	PROCESS	SAMPLING PERIOD	MAC-STAMP 68 (ppm)
12	Fin-press	8:15 - 11:25	12.71
12	Fin-press	11:25 - 15:30	11.51
03	#8 Automatic Bender	8:12 - 11:20	6.85
03	#8 Automatic Bender	11:20 - 15:30	15.56
03	#7 Automatic Bender	8:10 - 11:20	7.03
03	#7 Automatic Bender	11:20 - 15:30	4.41
03	#5 Automatic Bender	8:07 - 11:17	33.31
03	#5 Automatic Bender	11:17 - 15:30	29.93
03	Materials Handling	9:32 - 11:35	3.09
03	Materials Handling	11:35 - 15:25	3.64
3	Drop-saw Operator	9:35 - 11:25	N.D.
3	Drop-saw Operator	11:25 - 15:25	3.05
03	Automatic Bender	7:47 - 11:16	3.73
03	Supervising	7:50 - 11:17	2.59
03	Hand Bender	7:55 - 11:17	3.87
03	Automatic Bender	7:53 - 11:17	1.42
01	Hand Bender	9:12 - 12:12	1.74
19	Drying oven-capping coils	9:24 - 12:08	N.D.
19	Drying oven-capping coils	12:08 - 15:30	N.D.
19	Brazing on Mac-Stamp	8:55 - 11:28	4.14
19	Brazing on Mac-Stamp	11:28 - 14:45	3.00
19	Brazing on Mac-Stamp	8:58 - 11:30	2.19
19	Brazing on Mac-Stamp	11:30 - 14:45	1.73

N.D. = None Detected

TABLE II
BREATHING ZONE CONCENTRATIONS OF MAC STAMP 68 AND 1,1,1-TRICHLOROETHANE

BOHN ALUMINUM & BRASS CORP.
MAY 17 & 18, 1976

DEPT.	PROCESS	TIME	MAC-STAMP 68 (ppm)	1,1,1-TRI-CHLOROETHANE (ppm)
03	Automatic Bender #8	16:22 - 18:25	8.38	2.04
03	Dirving Jeep	16:08 - 18:30	2.45	1.95
03	Cutting copper tubing	16:03 - 18:17	3.25	2.09
03	Materials Handler	16:05 - 18:20	4.61	2.03
03	Automatic Bender #12	16:05 - 18:19	N.D.	N.D.
03	Materials Handler	18:20 - 22:10	6.97	1.74
03	Driving Jeep	18:30 - 22:00	13.25	1.80
03	Automatic Bender #8	18:23 - 22:12	23.27	2.29
03	Automatic Bender #12	18:18 - 22:01	14.53	2.31
03	Cutting Copper Tubing	18:17 - 22:01	1.93	7.50
03	Automatic Bender #12	8:30 - 14:32	5.92	2.73
03	Automatic Bender #6	8:25 - 14:32	28.06	3.38
	Automatic Bender #8	8:32 - 14:32	10.64	2.31
03	Automatic Saw	8:29 - 14:32	5.92	3.05
12	Fin Press	17:44 - 22:02	0.41	3.74
12	Fin Press	8:35 - 14:32	55.49	3.20
20s	Degreasing - Loads	16:36 - 18:33	0.48	5.46
20s	Degreasing - Unloads	16:42 - 18:34	0.77	16.58
20s	Degreasing - Loads	18:33 - 22:06	6.70	12.01
01	Degreasing	8:39 - 14:53	6.65	1.46

N.D. = None Detected

TABLE III
ENVIRONMENTAL CONCENTRATIONS OF METALS

BOHN ALUMINUM & BRASS CORP.
FEBRUARY 5 & 6, 1976

DEPT.	PROCESS	SAMPLING PERIOD	SILVER Conc.(mg/M^3)	CADMIUM Conc.(mg/M^3)	COPPER Conc.(mg/M^3)	ZINC Conc.(mg/M^3)
20f	Brazing - 35% Ag	8:10 - 11:12	N.D.	0.176	0.022	0.033
20f	Brazing - 25% Ag	8:16 - 11:10	N.D.	0.050	0.011	0.023
20f	Brazing - 35% Ag	8:20 - 11:13	N.D.	0.142	0.019	0.027
20f	Brazing - 35% Ag	8:22 - 11:11	.004	0.366	0.028	0.067
20f	Brazing - 35% Ag	8:13 - 11:13	.004	0.267	0.089	0.281
01*	Brazing - 35% Ag	8:35 - 15:13	N.D.	0.005	0.007	0.002
01	Brazing - 5% Ag	8:40 - 15:30	N.D.	0.002	0.010	N.D.
01	Brazing - 35% Ag	9:05 - 14:30	N.D.	0.008	0.010	0.004
19	Brazing - 0 or 5% Ag	8:58 - 14:35	N.D.	0.010	0.029	0.006
19	Brazing - 0% Ag	9:27 - 14:40	N.D.	0.009	0.021	0.004
19	Brazing - 0% Ag	8:55 - 14:45	N.D.	0.006	0.010	0.004
20s	Brazing - 0 & 5% Ag	10:30 - 15:15	N.D.	0.009	0.042	0.007
20s	Brazing - 0 & 5% Ag	10:35 - 15:05	0.005	0.007	0.037	0.007
20s&20f	Brazing - 0 & 5% Ag	10:40 - 15:12	0.002	0.022	0.034	0.010
20f	Brazing - 0 & 5% Ag	10:45 - 15:00	N.D.	0.026	0.018	0.016
Federal Standard (8-hr TWA)			0.01	0.1	0.1	5
TLV (c=ceiling)			0.01	0.05(c)	0.2	5

N.D. = None Detected
*Pump did not appear to be functioning at desired flowrate.

TABLE IV
BREATHING ZONE CONCENTRATIONS OF METALS

BOHN ALUMINUM & BRASS CORP.
MAY 17-19, 1976

BRAZING ALLOY (% Silver)	DEPT.	SAMPLE PERIOD	CADMIUM mg/M^3	COPPER mg/M^3	ZINC mg/M^3	SILVER mg/M^3
5	01	8:55 - 14:51	.001	.008	.003	N.D.
0,5	20f	9:52 - 14:55	N.D.	.008	.001	N.D.
0,5	20f	9:55 - 14:55	.001	.015	.002	N.D.
0,5	20f	9:59 - 14:57	.001	.029	.002	N.D.
5,35	01	8:49 - 14:48	.003	.013	.002	N.D.
35	01	8:43 - 14:49	.003	.007	.002	N.D.
0,5	01	7:58 - 14:50	.001	.011	.001	N.D.
0,5	01	8:52 - 14:46	.001	.010	.000	N.D.
0,5	20f	9:57 - 14:55	.001	.043	.005	.004
0,5	01	8:47 - 14:51	.001	.015	.002	.001
0,5	01	8:09 - 11:22	N.D.	.015	.001	N.D.
0,5	01	8:11 - 11:20	N.D.	.030	N.D.	.002
0,5	01	8:05 - 11:22	N.D.	.005	N.D.	N.D.
35	01	8:00 - 11:20	N.D.	.004	N.D.	N.D.
0,5	20	8:46 - 11:26	N.D.	.033	N.D.	N.D.
0,5	20	8:43 - 11:25	N.D.	.024	.003	N.D.
0,5	20	8:40 - 11:25	N.D.	.016	.002	N.D.
TLV mg/M^3			0.05	0.2	5	0.01
		JULY 28, 1976				
35 - half day 0,5 - half day	20	7:35 - 15:05	.003	N.D.	.007	N.D.
35 - half day 0,5 - half day	20	7:40 - 15:05	.009	.007	.012	N.D.
35 - half day 0,5 - half day	20	7:48 - 15:05	.003	N.D.	.005	N.D.
0,5	20	7:47 - 15:07	.003	.007	.005	N.D.
35	01	7:54 - 15:13	.035	N.D.	.019	N.D.
35	01	8:08 - 15:15	.015	.007	.005	N.D.
35	01①					
0,5	01	8:10 - 15:15	.014	.012	.023	N.D.

TABLE IV (Cont.)

BRAZING ALLOY (% Silver)	DEPT.	SAMPLE PERIOD	CADMIUM mg/M^3	COPPER mg/M^3	ZINC mg/M^3	SILVER mg/M^3
35 - half day 0,5 - half day	20	8:17 - 15:07	.049	.009	.071	N.D.
35	01	8:06 - 15:15	.022	.007	.007	N.D.
35	20	12:09 - 15:09	N.D.	N.D.	N.D.	N.D.
35	01	7:54 - 15:13	.047	.009	.016	N.D.
0,5	01	7:59 - 14:53	.003	.005	.004	N.D.
0,5	20	7:40 - 15:06	N.D.	.003	.003	N.D.
		JULY 29, 1976				
0,5	20	7:17 - 14:36	.008	.010	.010	N.D.
5,35	01	7:52 - 14:45	.185	.054	.045	.009
0,5	20	7:13 - 14:51	.010	.013	.013	N.D.
0,5	20	7:15 - 14:50	.012	.010	.015	N.D.
0,5	20	7:18 - 14:31	N.D.	.007	.003	N.D.
35	20	7:18 - 14:35	.014	.017	.007	N.D.
0,5	20	7:23 - 14:41	.007	.009	.009	N.D.
35	20	7:24 - 14:35	.056	.007	.058	N.D.
35	20	7:26 - 14:37	.027	.007	.026	N.D.
35	20	7:30 - 14:35	.035	.004	.033	N.D.
0,5	20	7:30 - 14:37	.037	.007	.036	N.D.
5,35	01	7:37 - 14:36	.061	.018	.039	N.D.
5,35	01	7:42 - 14:47	.013	.007	.005	N.D.
0,5	20	9:12 - 14:36	.012	.019	.014	N.D.
5,35	01	7:57 - 14:57	.019	.013	.015	N.D.
5,35	01	7:57 - 14:43	.032	.013	.011	N.D.

*Pumps were turned off during lunch break (approximately 30 minutes)

(1) Sample

N.D. = None Detected

TABLE V
ENVIRONMENTAL CONCENTRATIONS OF FLUORIDES

BOHN ALUMINUM & BRASS CORP.
JULY 28 and 29, 1976*

WORK STATION	DEPT.	SAMPLE PERIOD**	F (impinger) mg/M^3	+	F (filter) mg/M^3	=	TOTAL mg/M^3
1	20	8:48 - 15:08	.001		N.D.		.001
2	20	8:50 - 15:08	N.D.		N.D.		N.D.
14	01	8:54 - 15:14	.017		.112		.129
15	01	8:54 - 15:18	.021		.069		.090
16	01	8:55 - 15:16	N.D.		.009		.009
1	01	8:56 - 15:17	.007		.072		.079
3	01	8:56 - 15:15	.011		.046		.057
4	01	8:58 - 15:16	.022		.082		.104
1	20	7:50 - 14:37	N.D.		N.D.		N.D.
2	20	7:50 - 14:39	.010		N.D.		.010
14	01	7:55 - 14:46	.124		.060		.184
4	01	7:58 - 14:46	.010		.025		.035
16	01	7:54 - 14:45	.074		.058		.132
2	01	7:57 - 14:47	.064		.033		.097
3	01	7:56 - 14:47	.346		.073		.419

TLV = 2.5 mg/M^3

*During May, only 2 samples had detectable amounts (0.002 mg/M^3 each) of fluorides.

**All pumps except ninth and tenth on list were turned off during lunch break (approximately 30 minutes).

N.D. = None Detected

TABLE VI
HEAT STRESS MEASUREMENTS*

BOHN ALUMINUM & BRASS CORP.
JULY 29, 1976

	Times	WB	0.7 WB	GT	0.3 GT	WBGT
1	9:35	74.0	51.8	89.5	26.9	78.7
2	10:10	74.0	51.8	90.0	27.0	78.8
3	10:55	73.5	51.5	86.5	26.0	77.5
4	11:28	74.0	51.8	89.0	26.7	78.5
5	12:18	73.0	51.1	94.5	28.4	79.5
6	1:27	72.0	50.4	86.0	25.8	76.2
7	2:35	72.0	50.4	86.5	26.0	76.4
8	3:17	72.0	50.4	85.5	25.7	76.1

*Values given in °F, degrees Farenheit

PERMISSIBLE HEAT EXPOSURE*
THRESHOLD LIMIT VALUES
(Values Given in °C WBGT and °F WBGT)

WORK-REST REGIMEN	WORK LOAD LIGHT	MODERATE	HEAVY
Continuous Work	30.0(84°F)	26.7(80°F)	25(77°F)
75% Work 25% Rest Each Hour	30.6	28.0	25.9
50% Work 50% Rest Each Hour	31.4	29.4	27.9
25% Work 75% Rest Each Hour	32.2	31.1	30.0

°F = 9/5 C° + 32

°F = Degrees Farenheit
°C = Degrees Centagrade

*Taken from 1976 TLV's published by the American Conference of Governmental Industrial Hygienists

TABLE VII
COMPARISON OF SYMPTOMS BY HISTORY

BOHN ALUMINUM & BRASS CORP.
JULY 1976

SYMPTOMS	EXPOSED % POSITIVE		CONTROL % POSITIVE	
1. Cough	60%		50%	
2. Sputum Production	50%		39%	
3. Chest Tightness	45%	*	17%	P <.05
4. Wheezing	30%		22%	
5. Shortness of Breath	40%		44%	
6. Frequency of Urination 1/night	10%		17%	
7. Protein, sugar or blood in urine	5%	(Sugar)	0%	
8. Kidney or Bladder Problems	35%		28%	
9. High Blood Pressure in Past	10%		22%	
10. Chest Pain	20%		17%	
11. Heart Attacks	0%		0%	
12. Abnormal Blood Fats	0%		0%	
13. Miscarriages (female)	42%		12%	
14. Difficulties with Pregnancy (female)	8%		0%	
15. Deformities in Living Children	8%		0%	
16. Difficulties Fathering Children	0%		0%	
17. Headache	75%	*	28%	P <.01
Dizziness	60%		39%	
Trouble Sleeping	25%		17%	
20. Tremor	5%		6%	
21. Abnormal Sense of Smell	5%		17%	
22. Weight Loss	10%		11%	
23. Anemia	5%		6%	
24. Fatigue	30%		22%	
25. Loss of appetite	5%		6%	
26. Skin Rash	20%		6%	
27. Hepatitis or Liver Disease	5%		0%	
28. Frequent Colds	5%		6%	
29. Family Members who have died or or how have emphysema	35%		17%	

*Symptoms showing suggestive differences at or approaching statistical significance.

TABLE VIII

COMPARISON OF PHYSICAL EXAMINATION RESULTS
ABNORMALITIES

BOHN ALUMINUM & BRASS CORP.
JULY 1976

	EXPOSED % POSITIVE	CONTROL % POSITIVE
Blood Pressure (Abnormal Greater than 140/90)	35%	22%
Skin	0%	0%
Teeth (Edentoulous)	50%	50%
Lungs	0%	11%
Heart (Mummurs or Irregularities)	10%	0%
Smell	10%	0%

TABLE IX
BLOOD CADMIUM DETERMINATIONS
BOHN ALUMINUM & BRASS CORP.
JULY 1976

EXPOSED		CONTROL	
1.	<2.0 ug/DL	11.	<2.0 ug/DL
2.	<2.0 ug/DL	12.	<2.0 ug/DL
3.	<2.0 ug/DL	13.	<2.0 ug/DL
4.	<2.0 ug/DL	14.	<2.0 ug/DL
5.	<2.0 ug/DL	15.	<2.0 ug/DL
6.	<2.0 ug/DL	16.	<2.0 ug/DL
7.	<2.0 ug/DL	18.	<2.0 ug/DL
8.	<2.0 ug/DL	19.	<2.0 ug/DL
9.	<2.0 ug/DL	20.	<2.0 ug/DL
10.	<2.0 ug/DL	30.	<2.0 ug/DL
17.	<2.0 ug/DL	31.	<2.0 ug/DL
21.	<2.0 ug/DL	32.	<2.0 ug/DL
22.	<2.0 ug/DL	33.	<2.0 ug/DL
23.	<2.0 ug/DL	34.	<2.0 ug/DL
24.	<2.0 ug/DL	35.	<2.0 ug/DL
25.	<2.0 ug/DL	36.	<2.0 ug/DL
26.	<2.0 ug/DL	37.	<2.0 ug/DL
27.	<2.0 ug/DL	38.	<2.0 ug/DL
28.	<2.0 ug/DL		
29.	<2.0 ug/DL		

TABLE X

URINE CADMIUM DETERMINATIONS
ug/L Corrected for Specific Gravity (1.024)

BOHN ALUMINUM & BRASS CORP.

JULY 1976

EXPOSED		CONTROL	
1.	10	11.	8
2.	11	12.	10
* 3.	22	13.	8
4.	12	14.	4
5.	14	15.	12
6.	<4	16.	<4
7.	7	18.	<4
8.	<4	19.	12
9.	17	20.	8
10.	8	30.	5
17.	11	31.	<4
* 21.	27	32.	7
* 22.	15	33.	6
23.	7	34.	11
24.	14	35.	22
25.	4	36.	12
26.	6	37.	9
27.	8	38.	9
28.	7		
29.	7		
Mean	10.55	Mean	8.28
Standard Deviation	± 6.34	Standard Deviation	±4.82

*Worker abnormal, possibly related to cadmium exposure.

TABLE XI

HAIR CADMIUM CONCENTRATION
ug/Cd Per Gram Hair

BOHN ALUMINUM & BRASS CORP.
JULY 1976

EXPOSED		CONTROL	
1.	2.9	11.	0.7
2.	1.3	12.	1.1
*3.	3.0	13.	0.1
4.	3.5	14.	1.5
5.	4.9	15.	0.4
6.	2.3	16.	1.3
7.	2.3	18.	0.7
8.	2.6	19.	1.9
9.	1.0	20.	5.4
10.	0.7	30.	0.9
17.	1.7	31.	1.0
*21.	6.9	32.	8.0
*22.	2.2	33.	2.6
23.	0.6	34.	0.7
24.	0.6	35.	1.6
25.	1.0	36.	0.9
26.	2.4	37.	1.5
27.	9.2	37.	2.7
28.	2.0		
29.	1.4		
Mean	2.62	Mean	1.83
Standard Deviation	±2.2	Standard Deviation	±1.90

*Worker abnormal, possibly related to cadmium exposure

TABLE XII

PULMONARY FUNCTION STUDY RESULTS

EXPOSED BOHN ALUMINUM & BRASS CORP.

JULY 1976

WORKER	FVC (Liters) (PREDICTED)	FVC (Liters) (WORKER)	FEV_1 (Liters) (PREDICTED)	FEV_1 (Liters) (WORKER)	(Liters/Sec) FEF	(Liters/Sec) FEV_1/FVC
1	3.46	4.28	2.93	3.49	2.93	.815
2	3.59	4.45	3.10	3.80	4.10	.854
*3	3.20	3.74	2.69	2.50	1.22	.668
4	4.68	5.90	3.82	4.35	3.60	.737
5	4.66	5.14	3.78	4.46	4.90	.867
6	4.96	4.75	4.20	4.15	4.70	.874
7	3.10	2.95	2.69	2.36	1.72	.800
8	4.68	4.92	3.58	4.20	4.40	.854
9	3.36	3.20	2.88	2.90	3.50	.906
10	4.46	6.15	3.94	5.29	6.00	.860
17	3.84	4.42	3.30	3.36	2.20	.760
*21	2.48	1.85	2.25	1.22	0.65	.659
*22	4.46	5.80	4.00	3.80	1.90	.655
23	3.70	4.57	3.28	3.70	2.90	.810
24	3.82	4.55	3.28	3.77	3.35	.828
25	3.80	4.50	3.25	3.70	3.42	.822
26	3.57	3.95	3.18	3.52	4.30	.891
27	5.11	5.58	4.13	4.75	4.90	.851
28	3.60	4.18	3.10	3.65	4.50	.873
29	4.44	6.60	3.69	5.30	4.30	.803

Mean .809

Standard Deviation ±.076

*Worker abnormal, possibly related to cadmium exposure

TABLE XIII

PULMONARY FUNCTION STUDIES

BOHN ALUMINUM & BRASS CORP.

JULY 1976

CONTROL

	FVC (Liters)		FEV_1 (Liters)		(Liters/Sec)	
WORKER	(PREDICTED)	(WORKER)	(PREDICTED)	(WORKER)	FEF	FEV_1/FVC
11	3.39	3.92	3.00	4.25	3.00	.826
12	3.42	4.60	3.00	4.25	4.98	.923
13	3.15	2.85	2.70	2.10	1.52	.736
14	3.02	3.40	2.65	2.70	2.18	.794
15	3.56	3.97	3.01	3.48	3.38	.876
16	4.42	6.50	3.41	5.62	8.80	.865
18	3.30	3.48	2.88	2.78	2.49	.789
19	4.33	4.98	3.39	3.98	3.10	.799
20	5.24	6.30	4.24	6.20	6.30	.984
30	3.18	3.20	2.93	3.02	4.20	.943
31	3.92	4.12	3.44	3.08	2.08	.747
32	5.48	5.75	4.42	4.97	5.30	.864
33	5.26	5.30	4.22	4.08	2.90	.770
34	2.98	2.65	2.73	2.45	3.20	.924
35	4.90	5.70	4.03	4.42	3.20	.775
36	4.66	5.32	3.80	4.38	3.40	.823
37	4.62	5.08	3.94	4.10	3.55	.807
38	4.84	4.94	3.94	3.98	4.45	.840

Mean .838

Standard Deviation ±.070

TABLE XIV
BRAZIERS (Exposed)
CBC RESULTS

BOHN ALUMINUM & BRASS CORP.
JULY 1976

STUDY #	WBC/cc (Thousands)	RBC/cc (Millions)	HGBgm/dl	HCT%	MCVm^3	MCH pg	MCHC%
1	6.4	5.02	15.6	46.4	92	31	33.6
2	4.2	4.62	13.3	40.7	88	38.9	32.8
*3	8.3	4.92	15.9	46.9	95	32.3	33.9
4	7.4	5.40	16.5	48.9	90	30.5	33.7
5	5.1	4.98	14.9	43.1	86	29.5	34.1
6	4.9	5.08	15.4	45.9	90	30.4	33.7
7	7.4	4.72	14.5	44.0	93	30.8	33.1
8	7.7	5.10	16.4	47.4	92	32.1	34.6
9	7.2	4.10	12.0	36.4	88	29.4	33.1
10	5.3	4.96	14.7	43.7	87	29.7	33.7
17	8.0	4.43	13.0	39.9	89	29.3	32.6
*21	5.2	4.54	13.5	41.0	90	29.8	33.1
*22	6.5	5.29	15.5	46.2	87	29.4	33.7
23	7.6	4.55	12.3	37.2	81	26.9	33.1
24	6.2	4.60	14.1	42.6	92	30.6	33.2
25	7.9	4.59	14.1	42.2	91	30.7	33.5
26	4.5	3.58	9.4	29.7	82	26.4	31.9
27	8.1	5.55	16.8	49.7	89	30.3	33.8
28	6.5	4.76	14.3	42.4	88	30.1	33.8
29	4.9	5.11	16.0	46.9	91	31.4	34.2
Mean	6.5	4.80	14.4	43.1	89	29.9	33.4
Std. Dev.	±1.3	± .45	± 1.8	± 4.8	± 3.4	± 1.4	± 0.6

*Worker abnormal, possibly related to cadmium exposure

TABLE XV
CONTROL GROUP
CBC RESULTS

BOHN ALUMINUM & BRASS CORP.
JULY 1976

STUDY #	WBC/cc (Thousands)	RBC/cc (Millions)	HGBgm/dl	HCT%	MCVm^3	MCH pg	MCHC%
11	8.7	4.08	13.5	40.4	98	33.3	33.6
12	6.6	4.55	14.1	40.2	88	30.9	35.1
13	11.0	4.70	14.7	44.4	94	31.2	33.1
14	4.6	4.36	12.8	38.2	87	29.4	33.6
15	6.2	4.70	13.7	40.9	86	29.3	33.7
16	10.3	5.50	16.9	50.4	91	30.8	33.6
18	6.3	4.08	12.3	36.3	88	30.2	34.1
19	5.4	4.52	14.6	44.1	97	32.4	33.2
20	7.1	4.90	15.0	45.4	92	30.6	33.1
30	4.3	4.48	14.0	42.4	94	31.2	33.0
31	5.2	4.74	14.3	43.0	90	30.1	33.3
32	6.4	4.89	14.9	43.6	88	30.5	34.3
33	6.4	5.23	15.5	45.4	86	29.6	34.2
34	3.8	5.17	13.9	42.6	82	27.0	32.8
35	8.2	4.60	14.1	42.6	92	30.8	33.2
36	6.6	4.95	14.6	43.8	88	29.4	33.3
37	5.7	4.57	14.0	41.4	90	30.6	33.9
38	9.5	4.69	13.8	41.1	87	29.3	33.6
Mean	6.8	4.71	14.3	42.6	90	30.4	33.6
Std. Dev.	±2.0	± .37	± 1.1	± 3.1	± 4.1	± 1.3	±0.6

TABLE XVI
BRAZIERS (Exposed)
URINE AND BLOOD RESULTS

BOHN ALUMINUM & BRASS CORP.
JULY 1976

STUDY #	BUN (Blood Urea Nitrogen) mg/DL	URINE mg/Dl URIC ACID	URINE CREAT. mg/DL	BETA$_2$ MICROGLOBULIN URINE (4-370 ug/l)	ALPHA-1-ANTITRYPSIN BLOOD (165-389 mg/dl)
1	17	49	83	<30	260
2	17	50	76	<30	330
*3	17	22	52	<30	330
4	16	68	174	<30	210
5	16	36	93	<30	285
6	15	91	247	58	170
7	16	66	200	<30	210
8	19	57	131	55	260
9	9	23	62	40	210
10	18	100	290	340	210
17	10	36	126	<30	240
*21	15	53	122	<30	210
*22	15	21	65	<30	220
	10	16	49	<30	330
24	16	20	45	<30	420
25	18	66	155	<30	210
26	11	40	86	<30	275
27	20	69	194	<30	330
28	13	23	48	<30	330
29	25	66	200	<30	330
Mean	15.1	48.6	124.9	-	268.5
Std. Dev.	± 4.2	±24.4	± 72.2	-	± 64.7

*Worker abnormal, possibly related to cadmium exposure

TABLE XVII
CONTROL GROUP
BLOOD AND URINE RESULTS

BOHN ALUMINUM & BRASS CORP.
JULY 1976

STUDY #	BUN (Blood Urea (Nitrogen)mg/DL	URINEmg/DL URIC ACID	URINE CREAT.mg/DL	BETA$_2$ MICROGLOBULIN URINE (4-370 ug/l)	ALPHA-1-ANTITRYPSIN BLOOD (165-389 mg/dl)
11	20	24	54	<30	330
12	19	17	25	<30	420
13	17	24	35	<30	330
14	20	31	87	<30	420
15	12	16	35	<30	330
16	20	29	89	<30	130
18	17	50	132	32	330
19	19	77	196	<30	145
20	13	60	157	<30	210
30	13	48	100	<30	340
31	11	8	21	<30	360
32	18	69	154	<30	170
3	18	63	140	44	330
34	11	17	41	<30	330
35	14	25	40	<30	230
36	20	39	122	<30	210
37	15	66	204	<30	210
38	11	24	66	<30	330
Mean	16	38	94	-	286
	± 3.5	± 21.4	± 59.2		± 89.4

TABLE XVIII
SERUM CREATININE
Mg/DL
BOHN ALUMINUM & BRASS CORP.
JULY 1976

EXPOSED		CONTROL	
WORKER	SERUM CREATININE	WORKER	SERUM CREATININE
1	0.8	11	0.8
2	0.6	12	0.9
*3	0.7	13	0.8
4	0.9	14	0.9
5	0.8	15	0.7
6	1.0	16	1.2
7	0.8	18	0.9
8	0.8	19	1.1
9	1.6	20	0.8
10	0.8	30	0.7
17	0.9	31	0.6
	1.0	32	0.7
*22	0.9	33	0.7
23	0.8	34	0.8
24	0.8	35	0.6
25	0.8	36	0.8
26	0.8	37	0.9
27	0.8	38	0.8
28	0.7		
29	1.2		
Mean	1.2		0.8
Std. Dev.	± 0.2		±0.1

*Worker abnormal, possibly related to cadmium exposure

TABLE XIX
COMPARISON OF ALPHA-1-ANTITRYPSIN AND TOTAL
INHIBITORY CAPACITY BETWEEN EXPOSED AND CONTROL

BOHN ALUMINUM & BRASS CORP.
JULY 1976

EXPOSED			CONTROL		
WORKER	A-1-AT CONC gm/DL	TIC	WORKER	A-1-AT CONC gm/DL	TIC
1	2.25	0.84	11	4.20	0.63
2	2.40	0.79	12	5.60	1.05
*3	2.80	0.79	13	2.80	1.05
4	2.70	0.84	14	3.30	0.79
5	2.90	0.84	15	2.60	0.84
6	3.00	0.70	16	1.10	0.44
7	3.30	0.74	18	3.00	1.00
8	3.20	0.95	19	2.80	0.74
9	3.20	0.70	20	3.30	0.78
10	2.80	0.68	30	3.50	1.11
17	2.40	0.95	31	3.50	1.11
*21	3.30	0.82	32	1.90	0.74
*22	3.10	0.53	33	2.70	0.79
23	3.60	1.16	34	2.80	0.95
24	4.40	1.26	35	3.20	0.90
25	2.20	0.68	36	2.90	0.74
26	2.20	0.79	37	2.80	0.63
27	2.90	0.79	38	4.00	1.11
28	2.80	0.79			
29	4.20	0.79			
Mean	2.98	0.82		3.11	0.86
Std. Dev.	± .60	± .16		± .94	± .19

*Worker abnormal, possibly related to cadmium exposure

TABLE XX
SENSITIVITY AND IRRITANCY DATA ON "MAC-STAMP 68"

BOHN ALUMINUM & BRASS CORP.
JULY 1976

SKIN IRRITATION AND SENSITIZATION STUDIES "MAC-STAMP 68"

(1) SKIN IRRITATION (Rabbit Skin)

This material is a skin irritant at concentrations above 25% on intact skin and at concentrations above 10% on abraded skin.

(2) SKIN SENSITIZATION (Guinea Pig Skin)

This material did not sensitize guinea pig skin, however, a negative test does not completely rule out the possibility that it may be a human skin sensitizer.

Recommended patch test concentration on human intact skin is 10% and on abraded skin is 5%.