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. 76-25-359

QUINCY STEEL CASTING COMPANY, INC.
NO. QUINCY, MASSACHUSETTS

DECEMBER 1976

I. TOXICITY DETERMINATION

A National Institute for Occupational Safety and Health environmental survey team conducted a health hazard evaluation of the Quincy Steel Casting Company on March 17 and 18, 1976. Employees' exposures to a number of potential health hazards in several work areas have been evaluated. The following determinations are based on environmental measurements of contaminants, confidential employee interviews, a review of the pertinent literature, and observations of work practices and exposure controls.

Potentially toxic exposures to crystalline silica and iron oxide were present during the period of this survey. Excessive silica exposures were found in all areas of the foundry and cleaning room. At least nineteen of the 50 respirable silica samples taken exceeded NIOSH recommended criteria and 15 of these exceeded OSHA standards as well. Excessive iron oxide exposures occurred throughout the cleaning room and the torch cut-off operation. Both of these exposures are to the lung and may produce a combined potentiating effect greater than that expected from either individual exposure. Recommended control measures are given in this report.

Potentially toxic exposures were not found for lead, manganese, zirconium, fluoride, MDI, zinc, and isopropanol during the period of this survey.

Limited area samples for asbestos fibers were below the current 2 fiber per cc NIOSH recommended criteria. All but one (0.55 fiber/cc <5 um in length) was below the proposed reduced OSHA standard of 0.5 fibers per cc. The data was not sufficient to make a clear determination. See further actions recommended in the body of this report.

II. DISTRIBUTION AND AVAILABILITY OF DETERMINATION REPORT

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

Copies of this report have been sent to:

a) Quincy Steel Casting Company, Inc., N. Quincy, Massachusetts
b) Authorized Representative of Employees
c) U.S. Department of Labor - Region I
d) NIOSH - Region I

For the purpose of informing the approximately 40 "affected employees" the employer shall promptly "post" for a period of 30 calendar days the Determination Report in a prominent place(s) near where exposed employees work.

III. INTRODUCTION

Section 20(a)(6) of the Occupational Safety and Health Act of 1970, 29 U.S.C. 669(a)(6), authorizes the Secretary of Health, Education, and Welfare, following a written request by an employer or authorized representative of employees, to determine whether any substance normally found in the place of employment has potentially toxic effects in such concentrations as used or found.

The National Institute for Occupational Safety and Health (NIOSH) received such a request from the Quincy Steel Casting Company regarding the exposure of employees to silica dust. The primary motivation for this request was a concern over the observed loss of effectiveness in local exhaust systems. This was attributed to the installation of a large furnace shell exhaust system required to meet air pollution control standards. A strong negative air pressure was created in the foundry due to makeup air deficiency. The requestor also was concerned about noise exposures.

IV. HEALTH HAZARD EVALUATION

A. Process Description and Evaluation Design

This foundry produces only carbon steel. Its electric arc furnace has a 3000 pound capacity producing three or four heats per day. Total production last year was 1,200,000 pounds, however the total pounds of steel poured would be nearly twice that amount. This foundry has been in operation over 50 years. It employees five full time administrative, 36 production, and two maintenance personnel. Foundry activities have been grouped into seven functional categories as follows: Core Making, Mold Making, Melting, Pouring, Shakeout, Cleaning, and Sand Preparation which includes mulling, riddling and sand cleanup activities. Each area will be treated separately, however, the close physical relationship of these activities, as shown in Figure I, combined with the multiple work assignments of most employees requires the consideration of multiple exposures to each individual. General exhaust ventilation is provided by three large exhaust fans above molding, pouring, and shakeout areas respectively. A small wall fan provides little additional ventilation. The combined general exhaust is rated at 50,000 cfm. The multiple local exhaust systems have a combined rated capacity of 30,000 cfm of which 13,000 cfm is the furnace exhaust collection system.

The foundry normally operates on a 9-hour per day shift six days per week. Shifts start between 0500 and 0700 and end between 1430 and 1730 hours. A three man cleaning room crew works night shift. They were not surveyed since the heavier exposures would occur during peak daytime activities. Whenever possible sampling was done for the full term of the shift. Exceptions were samples taken for isopropanol and asbestos which were changed at varied intervals to collect peak loading information.

1. Sand Handling Process and Evaluation Design

a. Sand handling is accomplished by mullers and laborers as well as core and mold workers. Eleven 1000 pound batches of various types of sand are mixed daily. Green sand is used in molds, oil baked cores and airset molds and cores. Green sand is a mixture of 900 pounds single wash New Jersey sand, 60 pounds Bentonite, 100 pounds of corn flower; analysis of a grab sample showed the mixture to be 72% free silica. Oil baked cores require the addition of 9 pounds of linseed oil, 4.5 pounds of clay, and about 4% water content. For airset mixtures 188 pounds of AW 50 oil (with alkyd resin) and 3.6 pounds of lino Cure "C", which is the isocyanate component of the Ashland Chemical Company formulation, are added to the 900# Green Sand Mixture. The muller is loaded by a mechanical bucket lift. The lift is filled manually. After mixing the sand is delivered to each work location by wheel barrow where it is stored in bins or boxes until used. Used sand is recycled by processing the shakeout wastes through a riddle. The riddle sifts out slag and solid waste then blows the reusable sand 10 to 20 feet through the air into a storage bin. Analysis of a grab sample showed 84% free silica. A front end loader is used to feed the riddle and to remove waste to a dump truck for disposal. Riddling is a very dusty operation. For this reason it is usually done in the early morning or late evening when fewer workers are present. This operation is sometimes done during the day when the shakeout bin gets full. This was the case during our first day survey. The second day the front end loader removed waste products.

Wherever the term silica, free silica, or crystalline silica is used in this report it refers to that form of silicon dioxide (SiO_2) which has an orientation of its molecules in a fixed pattern as opposed to a nonperiodic, random molecular arrangement defined as amorphous silica. The three most common crystalline silica forms encountered in industry are quartz, tridymite and cristobalite.

b. Silica dust exposures were measured throughout the foundry; 57 respirable breathing zone samples and 8 high volume 9 lpm respirable area samples were collected. The samples were collected on two full period day shifts on March 17 and 18. Both muller operators, three laborers, three core makers, and six mold makers were instrumented on each shift. The remaining eight breathing zone samples were taken on cleaning room and maintenance personnel. Full period respirable area samples were taken in floor molding, squeeze molding, core making, mulling, shakeout and cleaning room areas.

2. Core Making Process and Evaluation Design

a. Cores are made by both oil bake and airset processes. Three men work in the oil bake process. Each worker performs all three functions forming, pasting, and wash coating. The core wash coat is a zirconium and clay mixture in an isopropanol carrier. Excess isopropanol is burned off. Two walk-in ovens are vented to the outside. The area has a small wall fan. Airset cores are made in an open area on a part time basis as required. The worker assigned these duties is also the leadman.

b. In addition to the silica dust sampling previously discussed workers exposure to isopropanol in the oil bake process and MDI in the core area were measured. Full term sequential breathing zone samples were taken for isopropanol exposure on two oil bake core makers each shift. In addition a series of area samples were taken at the work bench as well as peak measurements during burnoff. MDI area samples were taken on the airset core making bench during each shift.

3. Mold Making Process Description and Evaluation Design

a. Four types of mold making operations are used. Employees include three bench molders, two machine "squeeze" molders and four floor molders, one of whom is a part time air set molder. Sand is manually shovelled into the mold forms in each process. In green sand molds new sand is packed in first to provide a facing against the mold pattern and later the molten metal. This facing is backed up with recycled sand. The new sand facing enables a better finished casting surface. Inner mold surfaces are coated with the zirconium, clay, and isopropanol wash.

b. In addition to the respirable silica dust sampling previously described workers exposures to isopropanol in the green sand processes and MDI in the air set process were measured. Full term sequential breathing zone samples for isopropanol were taken for two shifts on two floor molders each shift. One breathing zone MDI sample was obtained for a three-hour period on the first day. Area MDI samples were collected for both shifts at the bench next to the airset mold making activity. Noise exposures were measured at the molding floor and molding machine operators locations for a number of sources.

4. Melting Process Description and Evaluation Design

a. Two melters and a ladle tender work full time in the furnace area, a fourth worker whose primary duties are chipper grinder may be called upon to assist or stand in during the absence of a melter. The arc furnace is charged manually. The melt capacity is 3,000 pounds and the pouring temperature is 3100°F. The furnace is equipped with a powerful 13,000 cfm exhaust collection system. The scrap used for charging is considered clean, primarily punched carbon steel. It is reportedly very low in non-ferrous metals and hydrocarbon contaminants. Additions made include 22 pounds of "as mined" fero silicon in a 50/50 two inch square lump form. Also added is 33 to 56 pounds of fero manganese to replace boil off losses. This is about 75% manganese. At the time of pouring 2 1/2 pounds of aluminum are added to each ladle. The furnace is lined with a silica clay mixture which was analyzed at 60% free silica. The three ladles are lined with a mixture which was analyzed at 24% free silica. The furnace and ladle linings require daily maintenance. Patches and repairs are made as necessary and ladles are relined once a month. The daily inspection of the furnace lining occurs in early morning. Major repairs are made on weekends usually requiring 2 1/2 hours of work in the furnace. The furnace is relined every six months. When the furnace is hot, the melters take turns accomplishing needed repairs. Routine access is through the charging hold which is too small to allow workers to wear sample pumps. When relining, the top of the furnace is removed.

b. In addition to the respirable silica dust sampling previously described, workers' exposures to airborne metal dusts and fumes were measured on both operators for one shift and one operator and the assistant on another shift. Drager colorimetric tube measurements of carbon monoxide (CO) and nitrogen dioxide (NO_2) were made.

5. Pouring Process Description and Evaluation Design

a. Pouring duties are intermittent usually requiring about thirty minutes three or four times per day. Workers are assigned this additional duty from molding, core making, mulling, and laborers. Pours are made directly from the large ladle transported by overhead crane when larger molds are poured. Small hand held ladles are carried by two workers when pouring smaller molds. They have recently begun using an asbestos fiber sleeve header in the fill hole of their molds. These used sleeves are present in shakeout sand and were observed to be easily broken up. A hot top powder is spread over the risers after pouring to control heat loss thus promoting uniform cooling.

b. In addition to the respirable silica measurements previously discussed pourers were instrumented for breathing zone metals dust and fumes sampling. Four full term samples were taken on each shift. Also colorimetric tube measurements of CO and NO_2, phenols, HCN and formaldehyde were made.

6. Shakeout Process Description and Evaluation Design

a. The shakeout operation is manual. Small castings are removed and pounded out in place on the pouring floor. Larger molds are moved by overhead hoist into the shakeout/riddle area. These are cleaned by striking with a mallet and probing with rods while hanging from the hoist. This activity consumes about 60% of the laborer/pourer shift.

b. Shakeout personnel were instrumented for respirable silica measurements. In addition the area was measured for asbestos fiber exposures.

7. Cleaning Process Description and Evaluation Design

a. Thirteen workers are involved in these activities. Cleaning operations are one torch cut off, two shot blast cabinets, two swing grinders, three pedestal grinders, three chipper/grinder booths, and two arc welders. Most processes were provided some degree of local exhaust. Exceptions were the torch cutoff, the maintenance welding booth and one pedestal grinder. Most cleaning activities are located in a cleaning room adjoining the foundry bay. Exceptions are the maintenance room welding booth, and three activities located in the bay on either side of the clean room door, namely torch cutoff, one shot blast unit, and a chipper grinder booth.

The large arc welding unit located in the cleaning room is a Lincoln 1200 amp semi-automatic using carbon dioxide shielding and bare rod. The ventilation for this unit was inoperative due to a frozen closed blast gate. The smaller 500 amp unit located in maintenance uses Westinghouse coated rods SWE 6013 which contain manganese. This welder utilized a welding helmet with face shield. The cutoff torch used propane and oxygen.

b. All workers in these activities were instrumented for respirable silica sampling. In addition eight breathing zone metal fumes and dust samples were collected for two shifts full term. The maintenance welders metals samples were taken inside the welders face shield. Both welding booths and the large swing grinding booth were sampled for fluoride dusts and gasses as possible contaminants from welding rod flux and grinding wheel decomposition. Arc welding exposures to ozone, NO_2, and CO were measured with colorimetric test tubes.

B. Evaluation Methods

Sampling and analytical methods for each contaminant were as follows:

1. Silica

a. Respirable crystalline silica dust was sampled using MSA Model G personal pumps and cyclones operated at 1.7 lpm. The samples were taken full shift where possible. An average sampling period of 7.9 hours was achieved. The area respirable samples were taken with Gelman pumps using a 1/2 inch stainless steel cyclone and a 9 lpm critical orifice.

b. Silica analysis was accomplished by x-ray diffraction. Quantities of quartz and cristobalite were observed. The sensitivity for quartz as well as cristobalite was only 0.04 mg/sample which results in a total sensitivity of 0.08 mg for the two analysis. Therefore, with sample volumes of less than 1 M^3 the actual lower limit of concentration measurements was on the order of 0.100 mg/M^3 of free crystalline silica. The calculated lower concentration detection levels are shown in Table I. No tridymite was detected even in 4 cubic meter high volume sample analysis with a sensitivity of 0.04 mg/sample.

2. Asbestos

a. Asbestos samples were taken using a MSA Model G pump at 2 lpm through an AA filter and open faced cassette. Samples were taken during peak loading periods as well as over extended one-half shift exposures in the mulling and shakeout areas.

b. Analysis was by microscope with phase contrast illumination at 400-450 magnification. Fibers less than 5 um in length were counted.

3. Metals

a. Metals were sampled with MSA Model G personal pumps through AA cellulose membrane filters in closed face cassettes at 1.5 lpm. Sampling periods were full shift whenever possible, an average sample period of 7.9 hours was achieved.

b. Analysis was accomplished by atomic absorption. The limits of detection were iron oxide 0.03 mg/sample, manganese 0.001, zirconium 0.2, lead 0.002, and zinc 0.002.

4. Isopropanol

a. Samples were collected on charcoal tubes with a Sipin pump at 200 cc/min. for a two to four hour period.

b. Analysis was accomplished by gas chromatography using carbon disulfide desorbtion. The limit of detection was 0.01 mg/sample.

5. Fluorides

a. Fluoride samples were collected using an MSA Model G sampling pump at a 1.5 lpm flow rate. The sample train was an AA cellulost membrane pre-filter in a closed face cassette followed by a midget impinger containing 15 ml of 15% sodium acetate solution. Area samples were taken for a full work shift.

b. Analysis for fluorides was by ion specific electrode. Limits of detection were 0.01 ug/ml for impinger analysis and 0.002 mg per filter. Drager tubes were used to detect peak hydrogen fluoride concentrations.

6. MDI

a. MDI was sampled using MSA Model G pumps with a midget impinger. Samples were collected in a 15 ml of a hydrochloric and glacial acetic acid absorbing solution at a sampling rate of 1.5 lpm. A 3 hour personal sample and four long term area samples were taken.

b. Analysis was accomplished by a colorimetric method. The possibility of interference from aromatic amines was considered. Side by side silica gel samples were taken with Sipin pumps at 200 cc/min. The limit of detection for MDI was 0.5 ug/sample.

7. Noise

Noise Measurements were accomplished with a General Radio Model 1565-B type 2. The instrument was calibration checked before and after field measurments with a General Radio Model 1562-A calibration unit. Both A and C weighted measurements were recorded at each data point.

C. Evaluation Criteria

1. There are a number of criteria quoted for the assessment of potentially toxic substances under investigation. Those with widest usage are the NIOSH Criteria Recommendations, the Threshold Limit Values (TLV) promulgated by the American Conference of Governmental and Industrial Hygienists, and third, the CFR Title 29 Part 1910.1000, used in OSHA enforcement. These three criteria are included here in Appendix I, Table 8. Their comparison can be made only with an understanding of the differences in methods of measurement and in intended degree of protection. The criteria which in our opinion represents the best health guide has been applied. The basis for the two positive determination criteria follows. (Please note that as is discussed in the next section of this report "Toxicology" the use of these criteria is not appropriate without consideration of the effects due to exposure to a combination of substances. Also note that these criteria must be adjusted downward by 25% when applied to a 54-hour work week.)

a. The criteria of 5 mg/M^3 for iron oxide[1] is based on the belief that this airborne concentration is sufficiently low to prevent the development of X-ray changes in the lungs on long-term exposure. More information is needed on the relationship of iron deposits in lungs to concomitant exposure to other industrial dusts.

b. The NIOSH criteria[2] recommended for respirable crystalline silica of 50 ug/M^3 (TWA) is based on the belief that this concentration is sufficiently low to protect workers from developing silicosis. In a comparison of the NIOSH recommended criteria with ACGIH TLV's it is noted that at high percent silica levels the ACGIH criteria approaches 100 ug/M^3 which is twice the NIOSH recommended exposure control level. This is computed from the ACGIH equation for TLV[1] of respirable quartz bearing dust as shown in Appendix I.

2. The toxicity of the two materials iron and silica for which positive determinations were made is discussed in detail in References 1 through 6. The limited information presented here is intended to provide layman with a general knowledge of the basis for these exposure criteria. The toxicology of the primary health hazards identified here is difficult to define in terms of recognizable symptoms since the effects are long-term. In the early stages of development a chest x-ray is the only means of diagnosing the onset of this illness. The classic definitions of siderosis which is a lung condition caused by exposure to iron dust and silicosis which is a lung condition caused by exposure to crystalline silica dust do not completely characterize the mixed dust

pneumoconiosis observed in steel foundry workers.[3,4] Furthermore the combined presence of iron dust which is opaque to x-rays and silica greatly increases the difficulty of diagnosing the degree of lung fibrosis which is the characteristic effect observed in clinical x-rays. It is this progressive fibrosis which ultimately causes impairment of respiration and disability. Symptoms occur when the condition which in this case will be referred to as either Mixed Dust Fibrosis or Silicosis, if only free silica exposures occur, advances after a period of exposure and becomes complicated by infection and emphysema. Continuous exposure to elevated concentrations of dust containing free crystalline silica with or without iron may produce increased debilitating effects. These changes are marked by intolerance to exertion, episodes of coughing and production of thick purulent sputum. When this condition has progressed to a certain degree in many cases it may progress in spite of termination of dust exposure[4] and become incapacitating to affected workers. There is an increased susceptibility to tuberculosis (TB) in exposed workers.

D. Evaluation Results and Discussion

1. Results

a. Sand mixing results in the highest overall worker exposures to airborne free silica dust. The four full term samples collected from mullers breathing zone were at least three to six times the NIOSH recommended criteria of 50 ug/M^3. The March 17 area sample was greater than ten times this criteria. Results are shown in Table 1. As previously discussed in Section B-1 it is not possible to state the maximum levels of exposure received due to the high detection limits.

b. Core makers exposures to silica dust did not average as high as the muller operators, however one of the six respirable personal samples was unusually high, 1.27 mg/M^3. The same workers exposure on the following day, as well as all the other core makers samples, were less than the laboratory detection limits, therefore as previously discussed (Section B-1) less than about 100 ug/M^3 which does not adequately define the exposure. Exposures to isopropanol were found to be well below the 980 mg/M^3 NIOSH recommended criteria. The highest TWA level measured was 50 mg/M^3. See Table 2 for isopropanol data. Peak concentrations of 300 ppm were observed during the coating process (brushing on) and 75 ppm during the burn off process. Peak measurements were taken with a JW-SSP dual range combustible gas indicator using the isopropanol calibration factor.

c. Four out of twelve mold makers exposures to respirable silica were above accepted limits. All three areas bench, floor, and machine molding were high. The remainder of the samples were inconclusive due to the high detection limits. Measured exposures were greater than 75 ug/M^3 for a floor molder, 110 ug/M^3 for a bench molder, and 144 ug/M^3 for a machine molder. The high volume floor molding area respirable silica sample was 148 ug/M^3. Isopropanol exposures to floor molders were generally below 20 mg/M^3, however, one two-hour exposure averaged 104 mg/M^3 which is well below the 980 mg/M^3 criteria.

d. Air set core and mold makers exposures to the MDI component of the resin binder system were measured at less than 1/10 of the 0.2 mg/M^3 criteria. See Table 3 for MDI data. No amines were detected in the side by side silica gel samples, therefore no interference was observed.

e. Melters exposures to respirable silica were measured by area and breathing zone samples. The respirable high volume area sample was .037 mg/M^3. However breathing zone samples were not conclusive due to the high level of detection. The fact that 50% of the area respirable sample was cristobalite and 50% quartz is significant for two reasons. First it demonstrates the presence of a high percentage of the more toxic form of crystalline silica. Second considering the fact that one of the four respirable breathing zone samples contained 44 ug/M^3 of quartz and that the detection limits for cristobalite would be 44 ug/M^3 for this sample volume of 0.9 M^3 it is probable that this sample would have exceeded the total 50 ug/M^3 crystaline silica criteria if the ratio of cristobalite to quartz were similar to that of the area sample. The other two melters samples would also be highly suspect of being just below the detection level since they were of a slightly smaller sample volume of 0.89 M^3 and 0.84 M^3 respectively. The melters helper was also sampled for silica. His time was divided between chipper grinder and melting the first day and was primarily grinding and chipping the second day. His exposures were 123 ug/M^3 and 105 ug/M^3 more than twice the recommended limit. Metals exposures were well within accepted limits for the melters however the helper was again shown to have a high exposure. He exceeded the TLV for iron oxide on the second day as did most of the cleaning room personnel. See Table 4 for Metals Data. Drager colorimetric tube readings in the furnace operators area were 5 ppm CO, <.05 ppm ozone, and <2.0 ppm nitrogen dioxide. The ladle heating area was also negative for CO and NO_2.

f. Pourers exposures to metals dust and fumes were measured in their breathing zone. None were found to be above accepted limits. Drager colorimetric tube readings were taken during two pours. On the first pour 1 ppm of CO was found at the center of the pouring floor and 15 ppm were measured over the small molds. Hydrogen cyanide over the castings was less than 2 ppm and formaldehyde <1 ppm. The second pour of larger molds found 100 ppm CO in the center of the pouring floor and 500 ppm directly over the large airset mold approximately 7 ft.X 3 ft. X 18 in. high. CO measurements were taken in adjacent mullers, shakeout, and machine molding work areas, however all were less than 10 ppm carbon monoxide. Phenol measurements over the mold were less than the TLV (5 ppm) by colorimetric tube test.

g. Shakeout workers and front end loaders operators were found to have significant exposures to respirable silica. Three of the six personnel samples ranged from two to six times the recommended criteria. The shakeout area sample was 80 ug/M^3 respirable silica 1/7th of which was cristobalite. This fact combined with an unusually high 220 ug/M^3 of cristobalite fraction in one of the breathing zone samples leads to the conclusion that exposures in this area are excessive.

Asbestos area samples taken in the course of various activities were either below the NIOSH recommended 2 fiber/cc criteria or were so overburdened with dust they could not be counted. See Table 5 for asbestos data. The fact that those countable were within the criteria is not sufficient to say that no exposure occurred since the most likely periods of high concentrations are during the riddling operation when the highest dust loading also occurs. This process should be kept under surveillance with periodic sampling for short periods so that countable samples are obtained to verify the absence of hazardous asbestos levels. Also personnel monitoring of shakeout and the front end loader operator is recommended. The asbestos criteria is under revision at this time. OSHA has proposed a reduction to .5 fibers/cc <5 um in length. ACGIH has proposed adding a caution that cigarette smoking can enhance the incidence of bronchogenic carcinoma. NIOSH is presently reviewing new information and will publish an update to its Asbestos Recommended Criteria Document.

h. Shot blasters' exposures to respirable silica were three times the criteria and half of this was cristobalite. Metals exposures were similarly high, one at three times the iron oxide criteria. This combination of excessive exposures is a serious threat to the health of these workers.

i. Grinders' and chipper grinders' exposures to respirable silica were in three out of nine cases in excess of the exposure criteria, one in each of the three grinding activities swing, pedestal, and hand. The cleaning room area respirable silica samples did not indicate these high exposure levels, however it is felt this is most likely due to the location of the samples adjacent to the doorway where air currents may have affected the results. Metals exposures to this group were uniformly high for iron oxide, 6 of the 8 samples were above the TLV. Fluoride levels were measured in the large swing grinding booth and were below the NIOSH recommended criteria of 2.5 mg/M^3. This was reasonable since communications with the abrasive wheel manufacturer indicated their alumina wheels contain no cryolite which is the common source of fluoride in grinding operations. See Table 6 Fluoride Data. Drager colorimetric tube tests for hydrogen fluoride in the large swing grinders breathing zone were <0.5 ppm.

Ventilation measurements taken in the chipper grinder booth showed no detectable flow at three feet in front of the slot on the work bench and about 400 to 600 fpm at six inches in front of the slots. All of the work was done three feet or greater from these slots. None of the slots were flanged or mobil. Ventilation face velocity measurements in the vertical plane of the face of the exhaust plenums in the back of the swing grinding booths were both undetectable at three feet above the floor and in the large grinder booth undetectable at four feet above the floor. In the small booth 150 fpm was observed at five feet above the floor. The design of the stand grinding exhaust system appeared appropriate however the metals exposure to the worker indicates that the system should be checked against design requirements for specific wheel sizes and rpm's.

j. Arc Welders and torch cutoff exposures to silica were measured. The cutoff workers exposure was greater than 159 ug/M^3 which is three times the recommended criteria. The welders exposures were inconclusive due to the high level of detection, however the cleaning room welder is considered to be at a risk due to the high levels found in activities throughout the room. Metals exposures were above the iron oxide TLV for the cleaning room welder and the cutoff worker. The metals samples for the maintenance room welder were taken from inside the welding helmet face piece and were all within normal limits. It should be noted however that this worker spends much of his time in chipping grinding activities where the additional exposures to silica and iron oxide dust are sufficient to place him at risk. The welders and torch cutoff worker in particular are considered to have a high potential for excessive mixed dust exposures. Drager colorimetric tube tests were taken for both arc welders exposure to ozone, nitrogen dioxide, hydrogen fluoride, and carbon monoxide. None of these were detected in the maintenance welding booth operators breathing zone. Colorimetric tube detection limits are .05 ppm ozone, 2.0 ppm nitrogen dioxide, 0.5 ppm hydrogen fluoride, and 5 ppm carbon monoxide. In the cleaning room welders breathing zone, 5 ppm of carbon monoxide was measured. Fluoride measurements taken in each of the arc welding booths were well below accepted criteria of 2.5 mg/M^3.

An extensive noise study was previously conducted by a private insurance company in February of 1972. Their analysis was directed at compliance with the 90 dB(A) OSHA standard. The report clearly identified a number of high noise exposure areas the worst of which was the chipper grinder who received 120-128 dB(A). Exposures throughout the cleaning area ranged in the high 90's and up. The exposures throughout the foundry were measured in excess of 90 dB(A) for certain molding, cutting torch, and furnace operations. The limited time of each of the exposures to the operator was considered to alleviate the condition for squeeze molders and floor molders.

During the course of this survey, only a few measurements were taken to determine the nature of the combined effects of exposures to molders, mullers, and furnace operations from the surrounding activities. See Table 7 for multiple noise exposure data. It was determined that the workers throughout the foundry floor molding area are frequently exposed to levels well in excess of 85 dB(A) and commonly above 90 dB(A) from their own activities as well as the activities in the other parts of the foundry. The total daily exposure could not be computed accurately on the basis of such limited observations, however, it is believed that the exposures are high.

2. Discussion

The clear presence of high levels of exposure to silica dust and iron dust is of primary concern in this foundry. The effects of a combined dust exposure in foundry workers have been recognized for some years. McLaughlin[4] has termed the disease of the lungs associated with such exposures as mixed dust pneumoconiosis. The TLV Documentation[1] clearly recognizes the potential for such combined effects. Both free silica and iron oxide were found in concentrations above their respective recommended control levels, however in these circumstances it is not appropriate to blindly apply these levels to the control of a mixed dust exposure since the combined long term effects are not fully understood. It has been documented that workers in foundries have an increased risk of lung disease.[1,2,3,4,5,6] Therefore the recommended practice of minimizing their exposures is well justified. The fact that effects of exposures to both iron and silica are delayed long term lung conditions makes it even more critical that every possible effort be made to reduce the total accumulated exposure. The difficulty of early diagnosis of mixed fibrosis by radiography results in an even greater burden being placed on preventive controls. Yet another factor is the lengthy 54-hour work week at this foundry which would reduce the TLV's quoted by a factor of 25%.

From the limited noise measurements taken during this survey and considering the previous 1972 insurance company noise survey it is clear that the foundry area is potentially hazardous to the hearing of the majority of the workers. In discussing the degree of damage risk it is necessary to address the question of an 85 dB(A) vs. a 90 dB(A) criteria for a "safe" 8-hour per day exposure level. This question has been debated at great length and while the legal OSHA standard is still 90 dB(A) a large number of professional authorities in the field consider 85 dB(A) to be the more acceptable level for protecting the majority of workers from receiving a significant neurosensory hearing loss. Recognizing that we are discussing the subject of criteria for a working population; the individual variability of workers dictates that precautions be taken to avoid injury to the more susceptible or sensative workers. It is considered appropriate to provide medical surveillance through a hearing conservation program for all workers exposed to 85 dB(A) for a significant portion of their work shift. This would apply to all of the workers in this foundry who work in production.

V. RECOMMENDATIONS

There are a number of methods of reducing the exposures to workers. A combination of them will result in the best working conditions economically feasible. The primary problem of silica dust can be corrected by the use of sands which contain a minimum of free crystalline silica and by providing closed systems with local exhaust where needed. The ventilation controls presently installed would be more effective if adequate replacement air were provided. As a prerequisite to any improvement in ventilation makeup air must be provided. A rule of thumb would require about 10% more makeup air than exhaust air. Makeup air intakes should be located where they will not pick up exhausted air. The makeup air should be introduced at low level, below 10 feet, to make best use of the clean air for cross ventilation and dilution in the workers breathing air. The requirement for filtration and conditioning of this air is dependent on local climatic and pollution conditions. The use of an enclosed sand riddling process will greatly reduce the level of airborne silica. Blowing of dry sand over any distance in an open room is not an acceptable practice. The use of a front end loader for waste disposal should be confined to evening hours after workers have departed so that dust can be removed by general exhaust before workers return. The loading of the sand mixer by manual handling and mechanical lift bucket caused high levels of exposure to the mixing crew. This process should be modified to reduce workers dust exposures. Premoistening of sand, mechanical loading, enclosed and hooded ventilation at sand loading locations are possible solutions.

Ventilation presently provided for shot blast and grinding will require evaluation after the replacement air problem is solved. The design of exhaust in the swing grinding and bench grinders and chippers booths were not adequate. Enclosures are necessary to control particulates ejected at high velocities. The design of exhaust systems makeup and recirculated air systems should be in accordance with the American Conference of Governmental Industrial Hygienists publication "Industrial Ventilation, A Manual of Recommended Practice."[7] It is available from ACGIH Committee on Industrial Ventilation, P. O. Box 16153, Lansing, Michigan 48901, at a cost of $8.00.

The welding and torch operations were not ventilated. The welding booth in the cleaning room had a slot exhaust which was inoperative. The control of iron oxide metal fumes is considered to be a major concern in view of the foundry's general exposures to silica dust. The cutoff torch operation appears to be the most serious exposure.

A properly designed ventilation system patterned after the specific examples in Section 5 of Reference 7 such as VS414 pg. 5-50 for Swing Grinders, VS413 pg. 549 for Portable Chipping and Grinding Tables, VS107 pg. 5-10 for Mixer and Muller Ventilation, VS416 pg. 5-52 for Welding Bench, VS416-1 for Flexable Duct Portable Welding Exhaust, VS916 pg. 5-110 for Torch Cutting Ventilation, VS 111 pg. 5-14 for Foundry Shakeout, and VS411 and 411-1 for Grinding Wheel Hoods should greatly improve the dust conditions. There will be a period of time during the design and implementation of this system when workers should be using respirators. There will be occasions during certain activities such as chipping out the inside of the furnace and ladle when it would be impractical to provide complete protection by exhaust systems. Again the respirators should be worn. This also is true during periods when open dry sand and slag handling is necessary such as waste disposal by front loader operator. It also is worth noting that the use of a welding helmet adds considerable protection from metal fumes which are deflected away from the breathing zone.

A respirator program must be established in accordance with OSHA Part 1910.134. This includes a basis for choosing the proper respirator, a respirator maintenance program, a worker training program, and a worker physical examination for proper fit and ability to wear a respirator. Some physical conditions prohibit the use of respirators.

In addition to these control measures it is necessary to conduct a thorough medical surveillance program. This should include preplacement, periodic, and termination physical examinations. In this way workers who have prior physical problems or who demonstrate unusual susceptability to the exposures present in a particular work area can be assigned work more suited to their physical abilities. The recommended medical surveillance is outlined in reference 2, Chapter I, Section 2. It must include emphasis on lung conditions, X-rays and pulmonary function tests, as well as work histories.

Annual audiograms should be reviewed carefully by professionals to identify early stages of progressive neurosensory hearing loss. Corrective measures including refitting of ear defenders and education should be followed up by more frequent audiograms. If the workers loss continues to progress he should be removed from hazardous noise exposures. Noise levels above 85 dB(A) are common throughout this facility. Ear defenders should be made available to all workers and their use encouraged. In the future procurement of pneumatic tools, special consideration should be given to their noise control specifications. The design of ventilation booths should take noise control into consideration as well. The field of noise control is highly specialized and will require expert consultants who have experience in treating similar problems. The exceptionally high noise exposure to chipping and grinding should receive first priority. Until this problem is controlled the practice of limiting workers exposure times must be continued as recommended in the insurance company study.

VI. REFERENCES

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5. ILO, Occupational Safety and Health Encyclopedia.

6. HEW, The Industrial Environment Its Evaluation and Control, 1973 Public Health Service Publication.

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APPENDIX I

CRITERIA COMPARISONS,
TABLES, GRAPH, AND SKETCH

TABLE 1

QUINCY STEEL COMPANY
FREE SILICA DATA
MARCH 17-18, 1976

Sample No.	Date	Type Work or Area	Sampling Period (hrs)	Sampling Volume (m)³	Quartz (mg)	Cristobalite (mg)	Respirable Free Silica Range X(mg/M³)		
399	3/17/76	Muller	8.38	.855	.15	< .04	.18	≤ χ <	.22
397	3/17/76	Muller	7.7	.785	.13	< .04	.17	≤ χ <	.22
371	3/18/76	Muller	8.62	.879	.32	< .04	.36	≤ χ <	.82
156	3/18/76	Muller	8.53	.870	.19	< .04	.22	≤ χ <	.26
206	3/17/76	Mulling Area	7.5	4.05	2.20	< .04	.54	≤ χ <	.55
394	3/17/76	Laborer	9.05	.923	.09	< .04	.10	≤ χ <	.14
778	3/17/76	Laborer	7.33	.748	< .04	< .04	---	χ <	.11
203	3/17/76	Laborer	7.37	.751	.06	.17	---	.31	---
384	3/18/76	Laborer	9.25	.943	.12	< .04	.13	≤ χ <	.170
180	3/18/76	Laborer	6.66	.680	< .04	< .04	---	χ <	.117
201	3/18/76	Front End Loader Operator Riddeling	2.3	.238	< .04	< .04	---	χ <	.336
77A	3/18/76	Shake Out Area	10.00	5.460	.36	.06	---	.08	---
389	3/17/76	Core Making OB	8.72	.889	1.13	< .04	1.27	≤ χ <	1.31
354	3/17/76	Core Making OB	7.95	.810	< .04	< .04	---	χ <	.099
219	3/17/76	Core Making OB	7.83	.722	< .04	< .04	---	χ <	.111
398	3/18/76	Core Making OB	7.78	.793	< .04	< .04	---	χ <	.101
348	3/18/76	Core Making OB	7.95	.810	< .04	< .04	---	χ <	.09
91	3/18/76	Core Making OB	4.93	.503	< .04	< .04	---	χ <	.159
94	3/17/76	Core Making Area OB	8.5	4.564	.53	.04	---	.125	---

TABLE 1 (Continued)

Sample No.	Date	Type Work or Area	Sampling Period(hrs)	Sampling Volume(m)^3	Quartz(mg)	Cristobalite(mg)	Respirable Free Silica Range X(mg/M^3)		
197	3/17/76	Molder, Machine	7.5	.765	.11	<.04	.144	≤ X <	.196
360B	3/17/76	Molder, Floor	7.45	.759	<.04	<.04		X <	.105
215	3/17/76	Molder, Bench	7.66	.782	<.04	<.04		X <	.102
165	3/17/76	Molder, Bench	7.12	.725	.08	<.04	.110	≤ X <	.165
388	3/17/76	Molder, Floor	6.16	.629	<.04	<.04		X <	.127
400	3/17/76	Molder, Floor	5.12	.521	<.04	<.04		X <	.154
86	3/18/76	Molder, Floor	7.97	.812	.06	<.04	.074	≤ X <	.123
211B	3/18/76	Molder, Floor	8.66	.884	<.04	<.04		X <	.090
377	3/18/76	Molder, Machine	7.62	.776	<.04	<.04		X <	.103
205	3/18/76	Molder, Bench	7.33	.748	<.04	<.04		X <	.107
187	3/18/76	Molder, Bench	7.25	.739	<.04	<.04		X <	.108
208	3/18/76	Molder, Floor	7.6	.775	<.04	.04	.051	≤ X <	.100
211A	3/18/76	Machine Molding Area	9.83	4.905	.09	<.04	.022	≤ X <	.026
51	3/18/76	Floor Molding Area	8.9	4.815	.63	.08		.148	
395	3/17/76	Melter/Chipper	8.75	.892	.11	<.04	.123	≤ X <	.168
84	3/17/76	Melter	8.25	.843	<.04	<.04		X <	.095
177	3/18/76	Melter/Chipper	9.33	.952	.06	.04		.105	
188	3/18/76	Melter	7.55	.768	<.04	<.04		X <	.104
213	3/18/76	Melter	8.9	.908	.04	<.04	.044	≤ X <	.088
54	3/17/76	Melting Area	8.0	4.368	.08	.08		.037	
76	3/17/76	Maintenance	6.1	.620	<.04	<.04		X <	.129
			3.85	.392	<.04	<.04		X <	.204
401	3/17/76	Shot Blaster	7.92	.807	<.04	<.04		X <	.099
154	3/18/76	Shot Blaster	7.92	.807	.07	.05		.149	
382		BLIND BLANK	--	.375	<.04	<.04	--	---	---
433	3/17/76	Large Swing Grinder	8.33	.850	<.04	<.04	--	X <	.094
176	3/18/76	Large Swing Grinder	8.0	.816	<.04	<.04	--	X <	.098
195	3/17/76	Small Swing Grinder	7.9	.805	.05	<.04	.062	≤ X <	.112
194	3/18/76	Small Swing Grinder	8.17	.833	<.04	<.04	--	X <	.096
362	3/17/76	Standard Grinder	8.0	.819	<.04	<.04	--	X <	.098
175	3/18/76	Standard Grinder	8.17	.833	.05	<.04	.060	≤ X <	.108

TABLE 1 (Continued)

Sample No.	Date	Type Work Or Area	Sampling Period(hrs)	Sampling Volume(m)3	Quartz(mg)	Cristobalite(mg)	Respirable Free Silica Range X(mg/M3)		
209	3/17/76	Old Chip & Grind Booth	8.37	.853	<.04	< .04	---	χ <	.094
95	3/18/76	Large Chip & Grind Booth	8.17	.833	.04	.05	--	.108	
87	3/18/76	Small Chip & Grind Booth	7.92	.807	<.04	< .04	--	χ <	.099
138	3/17/76	Cleaning Area	6.75	3.420	.07	< .04	.020	≤ χ <	.032
93	3/18/76	Cleaning Area	8.0	4.320	.13	< .04	.030	≤ χ <	.039
360A	3/17/76	Welding Booth	8.25	.841	<.04	< .04	--	χ <	.095
396	3/18/76	Welding Booth	8.17	.833	<.04	< .04	--	χ <	.096
96	3/17/76	Welding Room	7.33	.748	<.04	< .04	--	χ <	.107
155	3/18/76	Welding Room	7.58	.773	<.04	< .04	--	χ <	.100
378	3/17/76	Torch Cut Off	7.4	.754	.12	< .04	.159	≤ χ <	.212

TABLE 2

QUINCY STEEL COMPANY
ISOPOPANOL DATA
MARCH 17-18, 1976

Sample Location	Sample No.	Period (hrs)	Volume	mg/M^3
Core Making (oil baked) (BZ)	CT-1	2.00	.0259	22.35
	CT-2	3.08	.0372	16.13
	CT-3	0.70	.0077	23.38
Core Making (oil baked) (BZ)	CT-5	2.03	.0263	20.53
	CT-6	2.95	.0357	18.21
	CT-7	0.78	.0079	29.11
Bench Area	CT-9	2.03	.028	20.36
	CT-10	3.05	.0394	23.35
	CT-11	0.66	.0090	72.22
Floor Molder BZ	CT-13	2.00	.0045	104.44
	CT-14	2.00	.0269	21.56
	CT-15	3.38	.0414	13.51
	CT-16	4.33	.0498	13.25
	CT-17	4.17	.0566	6.54
	CT-18	1.00 (est)	.0121	5.79
	CT-19	7.12 (est)	.0854	4.10
	CT-20	3.13	.04121	9.95
	CT-21	6.41 (est)	.0769	11.28
	CT-22	5.57 (est)	.0668	15.11
	CT-23	5.11 (est)	.0613	15.64
Oil Baked Core Making (BZ)	CT-30	2.50	.0348	50.52
	CT-31	5.42	.0726	29.89
	CT-33	2.63	.0337	47.69
	CT-34	5.28	.0660	35.74
	CT-36	2.37	.0299	41.03
	CT-37	5.42	.0653	23.58
NIOSH Criteria				980.00

TABLE 3

QUINCY STEEL COMPANY
MDI DATA
MARCH 17-18, 1976

Date	Sample Location	Sample No.	Period (hrs.)	Volume	mg/M^3
3/17/76	Airset Mold Maker BZ	1	2.97	.178	.0134
3/17/76	Airset Mold Making Area	2	6.75	.405	.0113
3/17/76	Airset Core Making Area	3	6.75	.405	.0111
3/18/76	Airset Mold Making Area	4	8.87	.532	.0193
3/18/76	Airset Core Making Area	5	8.83	.530	.0173
	NIOSH Criteria				.2

TABLE 4

QUINCY STEEL COMPANY
METALS DATA
MARCH 17-18, 1976

	No.	Sample Period(hrs)	Vol(M)^3	Iron Oxide mg/M^3	Manganese mg/M^3	Zirconium mg/M^3	Lead mg/M^3	Zinc Oxide mg/M^3
Grinders	AAM-11	8.33	.750	8.84	.080	<.026	<.0027	.0514
	AAM-12	8.37	.753	5.96	.094	<.265	<.0027	.0513
	AAM-28	8.5	.765	6.90	.077	<.261	.0052	.586
	AAM-13	8.03	.723	5.13	.065	<.276	<.0028	.0336
	AAM-27	8.5	.765	4.02	.062	<.264	.0039	.074
	AAM-14	7.9	.711	1.24	.009	<.281	<.0028	.0436
	AAM-29	8.5	.765	8.09	.119	<.264	<.0026	.0067
	AAM-30B	8.25	.742	5.94	.082	<.027	.0040	.0688
Welders Automatic	AAM-17	7.58	.682	5.52	.231	<.293	<.0029	.0472
	AAM-31	8.16	.738	4.29	.185	<.272	<.0027	.0370
Manual	AAM-18**	7.5	.675	2.17	.087	<.296	<.003	.0220
	AAM-32**	7.58	.682	1.64	.090	<.293	<.0029	.0036
Torch	AAM-19	7.4	.666	8.37	.075	<.300	.006	.1173
	AAM-33	7.66	.690	6.71	.052	<.289	.0058	.0737
Shot Blaster	AAM-15	7.91	.715	3.65	.061	<.279	<.0028	.1405
	AAM-16	7.91	.715	16.65	.177	<.279	.0056	.0399
Melters	AAM-1	8.25	.744	.49	.075	<.268	<.0027	.4033
	AAM-25	7.53	.678	.59	.044	<.295	<.0029	.3438
(Melter & chipper)-worked grinding & chipping	AAM-3	8.75	.787	2.45	.128	<.254	.0038	.3624
	AAM-30A	8.2	.738	5.05	.081	<.271	<.0027	.0151
	AAM-26	8.9	.801	.31	.081	<.249	<.0025	.3824
Molder & Pourers Machine	AAM-4	7.5	.675	.91	.080	<.296	<.0030	.4813
Machine	AAM-23	7.53	.678	.63	.051	<.295	.0074	.2652
Bench	AAM-6	8.1	.729	.85	.041	<.274	.0055	.2432
Bench	AAM-24	7.3	.660	.33	.033	<.303	.0061	.2762
Machine	AAM-10	6.36	.573	.75	.103	<.349	.0035	.0757
Molding Other	AAM-8	6.88	.619	.46	.029	<.323	<.0032	.0521
	AAM-22	7.55	.679	.48	.022	<.294	.0059	.1151
Laborer Pourers	AAM-7	8.05	.726	.73	.062	<.377	.0041	.1708
	AAM-20	9.25	.832	.55	.027	<.240	.0096	.1535
	AAM-5	7.33	.660	.62	.193	<.303	<.003	.2273
Front End Loader	AAM-9	6.8	.612	.60	.044	<.326	<.0033	.0527
Loader	AAM-21	2.33	.210	1.28	.028	<.952	.0476	.0118
Criteria				5.0	5.0	5.0	.15	5.0

** Samples taken inside welding helmet face piece.

TABLE 5

QUINCY STEEL COMPANY
ASBESTOS DATA
MARCH 17-18, 1976

Date	Sample Location	Sample No.	Period (hrs.)	Vol (m^3)	Fibers <5 um/cc
3/17/76	Mulling Area	AASB-1	2.15	.258	*
		AASB-2	4.1	.494	*
		AASB-2A	1.33	.120	.12
3/18/76		AASB-7	0.25	.0225	.55 (0845-0900 - riddeling was over by 0800)
		AASB-8	0.25	.0225	<.07
		AASB-9	0.53	.048	.07
3/17/76	Shakeout (central area)	AASB-3	2.6	.312	*
		AASB-4	5.4	.620	.19
3/17/76	Pouring Floor	AASB-5	5.7	.694	.28
		AASB-6	UK	UK	** (240)
	NIOSH Criteria				2.0

* Filter so overloaded with dust that asbestos fibers could not be counted.

** Total Fibers - Due to recording error, unable to compute sampling period or therefore sample volume.

TABLE 6

QUINCY STEEL COMPANY
FLUORIDE DATA
MARCH 17-18, 1976

Area Surveyed	Type Sample	Sample No.	Period (hrs.)	Volume (m^3)	$\mu g/m^3$	Total
Small Swing Grinding Booth	Area Pre-Filter	FL-1A	7.25	.652	0.08	<1.61
	Area Imp.	FL-1B	7.25	.652	<1.53	
Large Swing Grinding Booth	Area Pre-Filter	FL-2A	7.25	.435	0.44	< 2.74
	Area Imp.	FL-2B	7.25	.435	<2.3	
Cleaning Room Welding Booth	Area Pre-Filter	FL-3A	3.67	.330	0.091	<3.94
	Area Imp.	FL-3B	3.67	.330	< 3.03*	
Maintenance Room Welding Booth	Area Pre-Filter	FL-4A	7.75	.697	0.04	<6.52
	Area Imp.	FL-4B	7.75	.697	<6.48**	

* Pump tipped over - lost some sample.
** Impinger sample leaked, limited sample volume available.

NIOSH Criteria 2,500 $\mu g/m^3$

TABLE 7

QUINCY STEEL COMPANY
NOISE SURVEY
MARCH 18, 1976

Sound Level Meter - General Radio 1565B, Type 2
Calibrator - General Radio 1562A
All measurements were taken indoors without a wind screen.

Location/Duty Where Measurements Taken	SPL Meter Reading		Primary Noise Source
	dBC	dBA	
Mullers Area	88	82	Background
	92	91	Squeeze Molders
	90	90	Chipping Booth
Floor Molders Area	98	95	New Model Pneumatic Ramer
	100	100	Old Model Pneumatic Ramer
	98	95	Chipping (from booth)
	95	90	Grinding (from booth)
	98	95	Squeeze Molder Ramer
	98	98	Squeeze Molder Vibrating
Furnace Area	95	90	From Furnace Operation
	95	91	Ladel Heating Jets

APPENDIX I

TABLE 8

TOXIC MATERIAL	MULTIPLE CRITERIA		
	NIOSH[a] RECOMMENDED	ACGIH TLV[b] 1975 Book	Title 29 Part 1910,[c] Subpart G
Crystalline Silica: Quartz	50 µg/M³ of all respirable Crystalline Silica	$\frac{10\ mg/M^3\ Resp\ Dust}{\%\ Quartz + 2}$	(from Table G-3)
Respirable Cristobalite and Tridymite		Use 1/2 (Quartz TLV Equation)	(from Table G-3)
Total Crystalline Silica	Not Recommended	$\frac{30\ mg/M^3\ Total\ Dust}{\%\ Quartz + 3}$	(from Table G-3) $\frac{30\ mg/M^3\ Total\ Dust}{\%\ Quartz + 2}$
Zinc Fumes		5 mg/M³	(from Table G-1)
Manganese	No Recommendation Published	5 mg/M³	None Published
Zirconium		5 mg/M³	(from Table G-1)
Iron Oxide Fume		5 mg/M³	10 mg/M³ (from Table G-1)
Lead	.15 mg/M³	.2 mg/M³	(from Table G-2)
Isopropanol		980 mg/M³	(from Table G-1)
Asbestos	$\frac{2\ fibers}{cc}$[d] < 5 µm	$\frac{5\ fibers}{cc}$[d] < 5um in length	(from 1910.93a)
MDI		.2 mg/M³	(from Table G-1)
Fluoride		2.5 mg/M³	(from Table G-1)

APPENDIX I

MULTIPLE CRITETIA TABLE - 8 (cont)

a. All NIOSH recommended criteria cited here are time weighted averages (TWA) designed to protect the health and safety of workers for up to a 10-hour workday, except lead which is for an 8-hour workday, 40-hour workweek over a working lifetime. Compliance with all sections of the applicable standard should prevent adverse effects on the health and safety of the workers.

b. American Conference of Governmental Industrial Hygienists Threshold Limit Value's refer to time-weighted average concentrations for a 7- or 8-hour workday and 40-hour workweek. They represent conditions under which it is believed that nearly all workers may be repeatedly exposed without adverse effects. These limits are intended for use in the practice of industrial hygiene and should be interpreted and applied only by a person trained in this discipline.

c. From the Code of Federal Regulations, Title 29 1910 Occupational Safety and Health Standards, Subpart Z Occupational Health and Environmental Controls, para. 1910.1000 air contaminants: any employee exposed to any material listed in Table Z-1, Z-2, or Z-3 of this section shall be limited in accordance with the requirements of the latest revision of this regulation. Criteria cited here from Tables Z-1, Z-2, and Z-3 all are based on an 8-hour work shift of a 40-hour workweek time weighted average exposure.

d. The asbestos criteria is undergoing revision at this time. OSHA has proposed a reduction to 0.5 fibers/cc <5um. ACGIH has proposed adding a caution that cigarette smoking can enhance incidence of bronchogenic carcinoma. NIOSH is presently reviewing available information to publish an update to its criteria document.

FIGURE 1

QUINCY STEEL CASTING COMPANY, INC.
NORTH QUINCY, MASSACHUSETTS