HEALTH HAZARD EVALUATION DETERMINATION REPORT

MHETA 80-101-9001

Jones and Laughlin Steel Corporation
Vesta No. 5 General Machine Shop
Mine ID # 3600960
Fredericksburg, PA

PREFACE

NIOSH conducts field investigations of possible health hazards in the workplace. These investigations are conducted under the authority of Section 20(a)6 of the Occupational Safety and Health Act of 1970, 29 U.S.C. 669(a)(6) and the Federal Mine Safety and Health Act of 1977, Public Law 91-173 as amended by PL 95-164 which authorizes the Secretary of Health and Human Services, following a written request from any employer or authorized representative of employees, to determine whether any substance normally found in the place of employment has potentially toxic effects in such concentrations as used or found.

NIOSH also provides, upon request, medical, nursing, and industrial hygiene technical and consultative assistance (TA) to Federal, state, and local agencies; labor; industry and other groups of individuals to control occupational health hazards and to prevent related trauma and disease.

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
CENTERS FOR DISEASE CONTROL
NATIONAL INSTITUTE FOR OCCUPATIONAL SAFETY AND HEALTH
MORGANTOWN, WEST VIRGINIA 26505

Final Report
Health Hazard Evaluation
MHETA 80-101-9001

Jones and Laughlin Steel Corporation
Vesta No. 5 General Machine Shop
Mine ID# 3600960

## I. SUMMARY


On October 11, 1979, the National Institute for Occupational Safety and Health (NIOSH) was requested by the United Mine Workers of America (UMWA) to conduct a health hazard evaluation of the Jones and Laughlin (J and L) Steel Corporation's Vesta No. 5 Mine General Machine Shop, located near Fredricksburg, PA. The request stated that there was a possibility of excess mortality among the welders of this shop.

A mortality study was initiated which is currently on-going and expected to be completed at a later date. Its results will be published as an addendum to this HHE report. An industrial hygiene survey of the shop was conducted in November, 1979. Welding fume samples indicated that some of the welders were overexposed to nickel, hexavalent chromium, and nitrogen dioxide when compared to the NIOSH recommended health standards for these substances. An interim report with recommendations was issued in June, 1980. Due to circumstances unrelated to this request, the shop reduced the number of welders from 15-17 to 2 and eventually closed entirely in May, 1982.

Based upon the results of this study, NIOSH has determined that there was significant overexposure to nickel, hexavalent chromium, and nitrogen dioxide during this survey. If this shop is ever reopened by J and L for maintenance welding operations as studied during this evaluation the recommendations contained in this report should be implemented.



Key Words: (SIC: 1211 Bituminous Coal Mine) Welding, nickel, hexavalent chromium, nitrogen dioxide.

## II. INTRODUCTION

This investigation was conducted in response to a valid HHE request per Section 501(a)(11) of the Federal Mine Safety and Health Act of 1977 submitted by Dr. Lorin Kerr, Director, Department of Occupational Health, UMWA, for NIOSH to investigate complaints of excessive mortality allegedly occurring among employees in the welding department of the Vesta No. 5 General Machine Shop.

The NIOSH response to this request consisted of two parts: 1) an assessment of worker exposure to toxic metal fumes, flux fumes, and gases generated during routine welding and cutting operations, and 2) a mortality study of past General Machine Shop workers.

A survey of worker exposure was conducted on November 14-15, 1979. An interim report was issued in June of 1980. The purpose of the interim report was to make available the findings and recommendations of the industrial hygiene survey prior to the issuance of the final report in order that appropriate corrective actions could be made in a timely fashion. The conclusion of the interim report was that there were significant overexposures during the survey to hexavalent chromium, nickel, and nitrogen dioxide when the welder's exposures were compared to the NIOSH recommeded health standards for these substances. The interim report recommended various control measures and work practices to reduce employee exposure to these and other contaminants. Copies of the interim report were sent to the union and the company. The union then requested a MSHA survey which was conducted on June 26, 1980. Only one welder was welding that day and only for 36 minutes. The results of the samples were all less than the MSHA TLVs, even when projected to a full shift operation. During this survey MSHA stated that MSHA could not take any action regarding the NIOSH interim report recommendations.

On July 24, 1980, a meeting was held between company representatives and NIOSH to discuss the interim report results.

Unrelated to this health hazard evaluation request J and L Steel decided to reduce the number of personnel in this shop due to the fact that one of the mines serviced by the shop had been sold. The company also announced its intention to close the shop entirely in the near future and, therefore, did not intend to install any form of exhaust ventilation. A meeting was held on August 29, 1980, between union and company officials. NIOSH was asked to participate to answer questions concerning the interim report. The union was interested in how the company would protect the remaining welders until the shop closed and requested a written commitment from the company that they install a local exhaust ventilation system if the shop ever re-opened. The company agreed only to issue appropriate respirators to the remaining welders and to put the question of local exhaust ventilation in abeyance until such time as the shop reopens. It is our understanding that the shop did close and remains so.

This report describes the industrial hygiene survey results, conclusions, and recommendations. The second part of the NIOSH response, the mortality study, is still on-going. Briefly, this study will be a retrospective cohort study. Past exposed General Machine Shop workers were identified from company records and followed to the present to determine their mortality experience. The number and causes of death were determined and the observed number will be compared with the expected number which is based upon the mortality experience of the United States general population, matched appropriately.

## III. PROCESS DESCRIPTION

The General Machine shop consists of a machine shop, a supply department, and a welding shop. The welding shop measured approximately 100 x 120 feet with a 30 foot ceiling (See Appendix C, Shop Diagram). A total of seventeen welders and one blacksmith worked in the welding shop - twelve welders and the blacksmith worked the day shift (8-3:15) and four welders worked the evening shift (3:30-10:30). The majority of the welding is shielded metal-arc welding (SMAW) using low hydrogen mild steel rods on clean mild steel base metal. For large piece fabrication a semi-automatic continuous welder is utilized. An oxy-acetylene torch is used for cutting and occasionally hardfacing. The types of welding rods used depend upon the base metal, the function of the piece, and the personal preference of the welder. These include mild steel, high manganese, hardfacing, and cutting and gouging rods. Occassionally, such metals as galvanized steel, cast iron, aluminum, stainless steel, and specialty steels - such as high manganese steel plate - are welded upon.

## IV. SURVEY DESIGN

### Methods

Welding fumes were collected using a Millipore AA filter mounted in a 2-piece cassette and a personal sampling pump calibrated at 1.5 Lpm. Each sample was analyzed for chromium, iron, manganese, nickel, and lead, using Inductively Coupled Plasma - Atomic Emission Spectroscopy (ICP-AES).

Samples for hexavalent chromium ($Cr^{+6}$) were collected using a polyvinyl chloride (FWS-B) filter mounted in a 2-piece cassette and a personal sampling pump calibrated at 1.5 Lpm. Each sample was analyzed by the s-diphenylcarbazide colorimetric method for $Cr^{+6}$. This procedure describes the analysis for $Cr^{+6}$ in the presence of other welding fumes.

Samples were collected and analyzed for nitrogen dioxide and nitric oxide using a triethanolamine (TEA) tube. These procedures correspond to NIOSH Method S321.

Samples were collected for gaseous and particulate fluorides using a Millipore AA filter and alkali impregnated backup pad mounted in a 2-piece cassette and a personal sampling pump calibrated at 2.0 Lpm. Sampling and analysis corresponded to the procedures described in NIOSH Method P & CAM 212.

Welding fume, hexavalent chromium, and fluorides were obtained by taping a filter cassette to the inside of the welder's helmet. This method of sampling provides a more accurate representation of the welder's actual exposure. If a welder switched from arc welding to oxy-acetylene cutting or welding or any other task not requiring a welding helmet, the filter cassette was moved to his collar. Nitrogen oxide samples were obtained in a manner similar to the welding fume samples.

## V. HEALTH EFFECTS AND EVALUATION CRITERIA

In welding and cutting processes the degree of risk present varies greatly with the type of welding equipment used, the type of base metal, the presence of any surface coatings (lead based paints, galvinizing), the type of welding rod, and the type of flux. The amount of exposure is determined by the work practices exhibited by the welder, the location of the welder relative to the arc, and the type and effectiveness of any control measures.

Many toxic substances can be generated including ozone, carbon monoxide, nitrogen dioxide, and various metal fumes (which varies according to the type of welding rod, base metal, and flux used). Reported toxic effects include simple irritation, metal fume fever, and lung diseases. There are reports in the literature of excessive exposure to nitrogen dioxide or ozone generated during confined space welding that resulted in acute pulmonary edema or pneumonitis.

The occupational health standards used by NIOSH to evaluate worker exposures when conducting a health hazard evaluation were obtained from various sources: NIOSH recommended occupational health standards, current ACGIH TLVs, and federal standards. NIOSH is not restricted to applying only federal (MSHA) standards when conducting a health hazard evaluation. Since the time the MSHA standards were promulgated more current research and epidemiological studies have prompted the ACGIH TLV committee to lower a number of their TLVs and NIOSH to recommend revising a number of existing federal standards. For the purposes of a health hazard evaluation NIOSH may select as evaluation criteria those exposure standards that best reflect current research. The evaluation criteria for this study were selected on this basis.

The table below contains the evaluation criteria used in evaluating the welder's exposures during the November, 1979, survey. For all the contaminants, except chromiun, nitric oxide, and fluorides, either the NIOSH recommended standards or 1980 ACGIH TLVs recommend lower exposures than the MSHA standards. The evaluation criteria are as follows:

| Substance | Evaluation Criteria NIOSH | ACGIH | Current MSHA Stds. |
|---|---|---|---|
| Chromium | ----- | $0.5mg/m^3$ | $0.5mg/m^3$ |
| $Cr^{+6}$ | $1ug/m^3$/1 | ----- | ----- |
| Iron oxide fume | ----- | $5mg/m^3$ | $10mg/m^3$ |
| manganese fume | ----- | $1mg/m^3$ | C $5mg/m^3$ |
| nickel | $15ug/m^3$ | $1mg/m^3$ | $1mg/m^3$ |
| lead | $0.10mg/m^3$ | $0.15mg/m^3$ | ----- |
| nitrogen dioxide | C $1.8mg/m^3$ (C 1ppm) | $6mg/m^3$ (3ppm) | C $9mg/m^3$ (C 5ppm) |
| nitric oxide | $30mg/m^3$ (25ppm) | $30mg/m^3$ (25ppm) | $30mg/m^3$ (25ppm) |
| fluorides | $2.5mg/m^3$ | $2.5mg/m^3$ | $2.5mg/m^3$ |

/1 1 ug = 0.001 mg.

## VI. RESULTS

Tables I through VI , Appendix A, contain personal and general area exposure data obtained during November 14-15, 1979 survey, in the General Machine Shop welding department. Indicated in Tables I, II, and III are the locations of each welder (referenced to Appendix A, Shop Diagram), the comtaminants monitored, and the welding process, welding rods, and base metals used. Tables IV, V, and VI indicate the location of the area samples and the contaminants monitored.

On November 14, 1979, seven welders on the day shift were monitored for exposure to welding fumes (chromium, iron, manganese, nickel, and lead), hexavalent chromium, nitrogen oxides, and fluorides, gaseous and particulate (Table I). One out of seven welders monitored was overexposed to inorganic nickel and two out four welders were overexposed to hexavalent chromium when compared to the evaluation criteria.

On November 15, 1979, the welders on the day shift were monitored for exposure to welding fumes (same as above), hexavalent chromium, nitrogen oxides, and flourides, gaseous and particulate (Table II). One out of ten welders monitored was overexposed to inorganic nickel and four out of four welders monitored were overexposed to hexavalent chromium. Three out of the five 15-minute personal samples exceeded the NIOSH recommended ceiling standard for nitrogen dioxide. The blacksmith was monitored for exposure to respirable dust. His exposure was below the evaluation criteria for respirable dust.

On November 15, 1979, three welders on the evening shift were monitored for exposure to welding fumes (same as above). Exposures to the substances monitored were, in all three cases, less than the evaluation criteria (See Table III).

## VII. DISCUSSION

As can be seen from Tables I and II, those welding operations associated with welding fume overexposure or possible overexposure were hardfacing operations at welding stations 2,5,6, and 8. Hardfacing welding rods have high chromium and nickel contents resulting in the generation of welding fumes containing these metals.

The welding operations associated with nitrogen dioxide overexposure were welding stations 1 and 6.

Controls present at the time of the survey consisted of four three foot ceiling fans and one small fan located eight feet up the wall near welding station 1. The size of the shop, 110 x 120 x 30 feet, allowed for a significant amount of dilution of welding fumes to occur. All windows and doors were closed due to the seasonal cold weather. Man-coolers (pedestal mounted fans) were present but not in use. According to a number of shop workers the man-coolers were not used to blow welding fumes away from the welders due to the adverse cooling effect on the weld but instead were used during the summer months for general cooling purposes.

Controls for the blacksmith forge consisted of an air injector operated canopy hood. Observations indicated that this hood was ineffective in controlling the smoke and gases coming off of the forge as evidenced by the amount of smoke that escaped the hood to enter the shop environment. Employee interviews indicate the forge was used three to four times per week and was a source of irritating and objectionable smoke. Coal as used in this forge is known to give off carbon monoxide and other harmful substances.

Observations made during the survey indicate that the welding fumes build up rapidly when more than four welders are working as evidenced by the visible blue haze present in the shop. Workers complained of cough, nasal and throat irritation, and dryness of the mouth and throat due, presumably, to welding fumes and gases.

The company contends that there were more welders than normal welding during the survey and that the personal exposures were not representative of a normal day. The data do not support the contention that overexposures reflect the inordinately large number welding during the survey. Subtracting the area exposures from the personal samples would reduce some, but not all, of the values to below the evaluation criteria. It appears that each welder's exposure was primarily dependent upon the fumes he personally generated; therefore, in our opinion, these exposures were considered representative of normal shop welding operations.

It can be seen from Tables IV and V that the levels of nitrogen dioxide, and irritant gas, in the general area of the weld shop were significantly elevated. Although the general area nitrogen dioxide levels do not exceed the NIOSH recommended ceiling standard of 1.8 mg/m$^3$ we feel that the general area nitrogen dioxide exposure coupled with general area metal fume and forge smoke exposure contribute to the complaints of irritation and dryness.

## VIII. CONCLUSIONS

Despite the natural dilution ventilation due to the large volume of the shop and the mechanical dilution ventilation provided by the ceiling fans there were, on the days of the survey, significant overexposures to toxic welding fumes - nickel and hexavalent chromium - and nitrogen dioxide at four of the eight welding stations in use.

The smoke escaping from the canopy hood above the blacksmith forge may contribute significantly to the overall levels of airborne particulates in the welding shop and represents a possible source of carbon monoxide and other toxic substances. The present canopy hood is ineffective in controlling emissions from this forge.

Employee interviews revealed that occasionally galvanized steel is welded upon. The welding fumes generated from galvanized steel typically contain zinc and sometimes lead. The American Welding Society recommends that indoor welding on zinc-bearing materials be controlled through local exhaust ventilation (1).

Employee interviews revealed that occasionally such materials as aluminum, stainless steels, and specialty steels are welded upon.

Respirators were not in use at the time of the survey nor did J and L have a respiratory protection program for these workers.

## IX. RECOMMENDATIONS

A. Mechanical local exhaust ventilation should be provided for welding stations 1, 2, 6 and 8 in order to eliminate or control welding fume exposure to levels below applicable recommended health standards. Local exhaust ventilation may be provided by one of the following means:

1. Freely movable hoods intended to be placed by the welder as near as practicable to the work being welded and provided with a rate of air flow sufficient to maintain a minimum velocity in the direction of the hood of 100 linear feet per minute in the zone of welding (1). (See Appendix B, Figures 1 and 2)

2. A ventilated fixed enclosure (cross draft table with a top and not less than two sides which surround the welding and cutting operations and with a rate of air flow sufficient to maintain a velocity away from the welder of not less than 100 linear feet per minute (1). (See Appendix B, Figure 3)

3. Downdraft ventilation tables with a minimum of 150 cubic feet per minute per square foot of surface area. This rate of exhaust air shall be uniform across the face of the grill [1]. (See Appendix B, Figure 4)

4. A low volume, high velocity fume eductor attached to the welding gun (designed primarily for continuous welding applications) [1]. (See Appendix B, Figure 5)

B. The mechanical local exhaust ventilation system(s) should be designed to meet the performance specifications found in A., installed, and tested to assure performance per design by someone familiar with such work.

C. Welding on stainless steels and galvanized materials should be performed only at welding stations provided with local exhaust ventilation is recommended in A.

D. Employee interviews revealed that on a day-to-day basis the base metals and type of welding rods used at each station may change possibly resulting in substantially different exposures. In order to provide maximum flexibility to the welding shop operations and <u>assure</u> that exposures at all weldings are below applicable recommended health standards local exhaust ventilation as in A. should be provided for all the shop stations.

E. Good industrial hygiene practices dictate that when welding or cutting on aluminum, cast iron, and specialty steels local exhaust ventilation as recommended in A. should be provided in order to assure toxic fume and gas exposure remain below applicable recommended health standards.

F. As an interim protective measure NIOSH/MSHA approved metal fume respirators should be provided the welding shop employees until such time as the local exhaust ventilation system(s) is installed.

G. NIOSH/MSHA approved metal fume respirators should be used in those instances where local exhaust ventilation is not available - either inside the shop or elsewhere and any of the following operations are performed:

1. hardfacing

2. brazing

3. welding on aluminum, galvanized metals, stainless steels, and specialty steels, and any other metals containing toxic materials.

H. Those welders who would have occasion to use metal fume respirators should be instructed in the proper use, fitting, cleaning, and maintenance of respirators. Implementation of an on-going respiratory protection program incorporating the major elements of the American National Standard Practices for Respiratory Protection, ANSI Z88,2-1969, should be considered for these employees.

I. An on-going employee education program should be initiated to train employees in:

   1. the proper use and maintenance of the local exhaust ventilation system, and

   2. health hazards associated with welding and cutting operations. (See reference 1)

J. Employee interviews revealed that occasionally welding is done in confined spaces outside the shop area. Certain minimum health and safety procedures are necessary in such instances:

   1. All welding and cutting operations carried on in confined spaces should be adequately ventilated to prevent the accumulation of toxic fumes and gases or possible oxygen deficiency.

   2. In such circumstances where it is impossible to provide such ventilation, positive pressure air supplied respirators or hose masks approved by NIOSH/MSHA should be used.

   3. A worker shall be stationed on the outside of the such confined spaces to ensure the safety of those working within.

K. The local exhaust ventilation system for the blacksmith forge should be upgraded by replacing the present compressed air (vacuum principle) system with a centrifugal fan exhausting to the outside and providing better hood capture characteristics by enclosing or partially enclosing one or two of the open sides. The system should provide a capture velocity of 100-150 feet per minute as measured at the perimeter of the forge [2]. (See Appendix B, Figure 6)

L. Lead chromate corrosion resistant paint was being used to spray (spray can) and brush paint finished pieces. According to employee interviews this type of paint is used on all the underground vehicles. Because of the inherent toxicity of both lead and chromate we recommend:

   1. A less toxic substitute be used, or

   2. When welding or cutting on metal painted with lead based paints that the paint first be removed with either a stiff wire brush or grinder. If available, local exhaust ventilation should be used to control possible exposure to lead fumes in addition to the welding fumes, otherwise a NIOSH/MSHA approved metal fume respirator should be worn.

3. Spray painting of finished pieces with lead based paints should be done either outside or in an adequately ventilated paint spray booth. Care should be taken to avoid breathing the overspray, otherwise a NIOSH/MSHA approved combination organic vapor/mist respirator should be worn.

## X. REFERENCES


1. American Welding Society. Safety in Welding and Cutting, ANSI Z49.1-1973.
2. American Conference of Governmental Industrial Hygienists. Industrial Ventilation, 1978.


## XI. AUTHORSHIP


Report Prepared by: Paul Hewett
Industrial Hygienist
Environmental Investigations Branch
Morgantown, West Virginia

Medical Consultation: Ashok Patil, M.D., M.P.H.
Medical Officer
Clinical Investigations Branch
Morgantown, West Virginia

Originating Office: Mining Health Evaluations and Technical Assistance Program
Division of Respiratory Disease Studies
Morgantown, West Virginia

Report Typed by: Deanna M. Cress
Clinical Investigations Branch
Morgantown, West Virginia

APPENDIX A

TABLE I

GENERAL MACHINE SHOP WELDING SHOP

PERSONAL EXPOSURE DATA

NOVEMBER 14, 1979, FIRST SHIFT

Time Weighted Averages(2) ($mg/m^3$)(3)

| Welder Location | Chromium | Iron | Manganese | Nickel | Lead | Hexavalent Chromium | $NO_2$(4) | Fluorides | Process Description (Welding Method/Rod/ Base Metal |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 0.012 | 1.104 | 0.135<br>0.257[4] | 0.003 | 0.005 | | LLQ(5)<br>LLQ<br>LLQ | | SMAW(6)/E6012 Manganend 1M/mild steel |
| 1 | 0.014 | 0.863 | 0.119 | 0.003 | 0.006 | | | 0.129 | SMAW/E6012, Manganend 1M/mild steel |
| 2 | 0.023 | 0.991 | 0.102 | 0.010 | 0.003 | LLD(11) | | | SMAW/LH110/hardfaced mild steel |
| 5 | 0.015 | 1.535 | 0.134 | 0.014 | 0.016 | | | 0.208 | SMAW, O/A(7)/LH110/ mild steel |
| 6 | 0.051 | 0.790 | 0.107 | 0.013 | 0.004 | 0.016 | LLQ<br>LLQ | | SMAW (hardfacing)/ Hardalloy 48/mild steel |
| 6 | 0.237 | 1.351 | 0.113 | 0.061 | 0.004 | 0.135 | LLQ<br>LLQ | | SMAW (hardfacing) Hardalloy 48/mild steel |
| 8 | 0.009 | 2.072 | 0.086 | 0.003 | 0.005 | LLD | | 0.092 | Grinding, O/A hardfacing/ Colmonoy No. 6/mild steel |
| Evaluation Criteria | 0.5[8] | 5.0[8] | 1.0[8] | 0.015[10] | 0.1[10] | 0.001[10] | C[9]1.8[10] | 2.5[10] | |

(1) See Appendix A, Shop Layout
(2) Except where otherwise noted
(3) Milligrams per cubic meter
(4) Represents 15 minute sample for comparison to ceiling value
(5) Less than the Limit of Quantitation
(6) Shielded-Metal Arc Welding
(7) Oxy-acetylene torch
(8) 1980 ACGIH recommended TLV
(9) Ceiling Value
(10) NIOSH recommended health standard
(11) Less than Limit of Detection

APPENDIX A
TABLE III
GENERAL MACHINE SHOP WELDING SHOP
PERSONAL EXPOSURE DATA
NOVEMBER 15, 1979, SECOND SHIFT

Time Weighted Averages($mg/m^3$)

| Welder Location 1 | Chromium | Iron | Manganese | Nickel | Lead | Process Description (Welding Method/Rod/ Base Metal) |
|---|---|---|---|---|---|---|
| 1 | 0.008 | 0.601 | 0.075 | 0.003 | 0.001 | SMAW/E7018/mild steel |
| 3,6,7 | 0.001 | 0.831 | 0.039 | 0.001 | 0.002 | SMAW,OA semi-automatic/ Lincoln Innershield (AWS A5-20) NS-3M, E6012/ mild steel |
| 3,6,7 | 0.001 | 0.819 | 0.025 | 0.001 | 0.001 | carbon arc cutting, O/A cutting, SMAW/E6012/ mild steel |
| Evaluation Criteria | 0.5[2] | 5.0[2] | 1.0[2] | 0.015[3] | 0.1[3] | |

(1) See Appendix A, Shop Layout
(2) 1980 ACGIH recommended TLV
(3) NIOSH recommended health standard

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 4 | 0.011 | 0.711 | 0.036 | 0.002 | 0.004 | | | | SMAW/E6012/mild steel |
| 6 | 0.033 | 0.600 | 0.046 | 0.010 | 0.003 | 0.012 | 3.8 | | SMAW (hardfacing/ Hardalloy 48/mild steel |
| 6 | 0.047 | 1.198 | 0.061 | 0.012 | 0.005 | 0.014 | LLQ | | SMAW (hardfacing/ Hardalloy 48/mild steel |
| 7 | 0.021 | 0.626 | 0.042 | 0.005 | 0.005 | | | 0.006 | SMAW/E6012/mild steel |
| 8 | 0.019 | 0.314 | 0.026 | 0.004 | 0.004 | 0.010 | | | O/A hardfacing/Colmonoy No. 6/mild steel |
| 6 | | (Respirable dust 1.17 mg/m$^3$)(4) | | | | | | | (forge) |
| Evaluation Criteria | 0.5[5] | 5.0[5] | 1.0[5] | 0.015[6] | 0.1[6] | 0.001[6] | C1.8 | 2.5[6] | |

(1) See Appendix A, Shop Layout
(2) Except where otherwise noted
(3) Represents 15 minute sample for comparison to ceiling value
(4) 1980 ACGIH recommended TLV - 5 mg/m$^3$
(5) 1980 ACGIH recommended TLV
(6) NIOSH recommended health standard

APPENDIX A
TABLE V
GENERAL MACHINE SHOP WELDING SHOP
GENERAL AREA EXPOSURE DATA
NOVEMBER 15, 1979, FIRST SHIFT

Time Weighted Averages (mg/m$^3$)

| Area Sampler Location | Chromium | Iron | Manganese | Nickel | Lead | Hexavalent Chroming | $NO_2$ | NO |
|---|---|---|---|---|---|---|---|---|
| 1 | 0.041 | 0.387 | 0.051 | 0.006 | 0.003 | | 0.3 | 0.1 |
| 2 | 0.037 | 0.342 | 0.035 | 0.004 | 0.001 | | | |
| 4 | 0.017 | 0.275 | 0.022 | 0.003 | 0.002 | | | |
| 6 | 0.046 | 0.486 | 0.047 | 0.008 | 0.002 | 0.019 | 0.4 | 0.2 |
| 8 | 0.040 | 0.299 | 0.029 | 0.004 | 0.002 | LLD[2] | 0.4 | 0.2 |
| Evaluation Criteria | 0.5[3] | 5.0[3] | 1.0[3] | 0.015[4] | 0.1[4] | 0.001[4] | C1.8[4] | 30[4] |

(1) See Appendix A, Shop Layout
(2) Less than the Limit of Detection
(3) 1980 ACGIH recommended TLV
(4) NIOSH recommended health standard

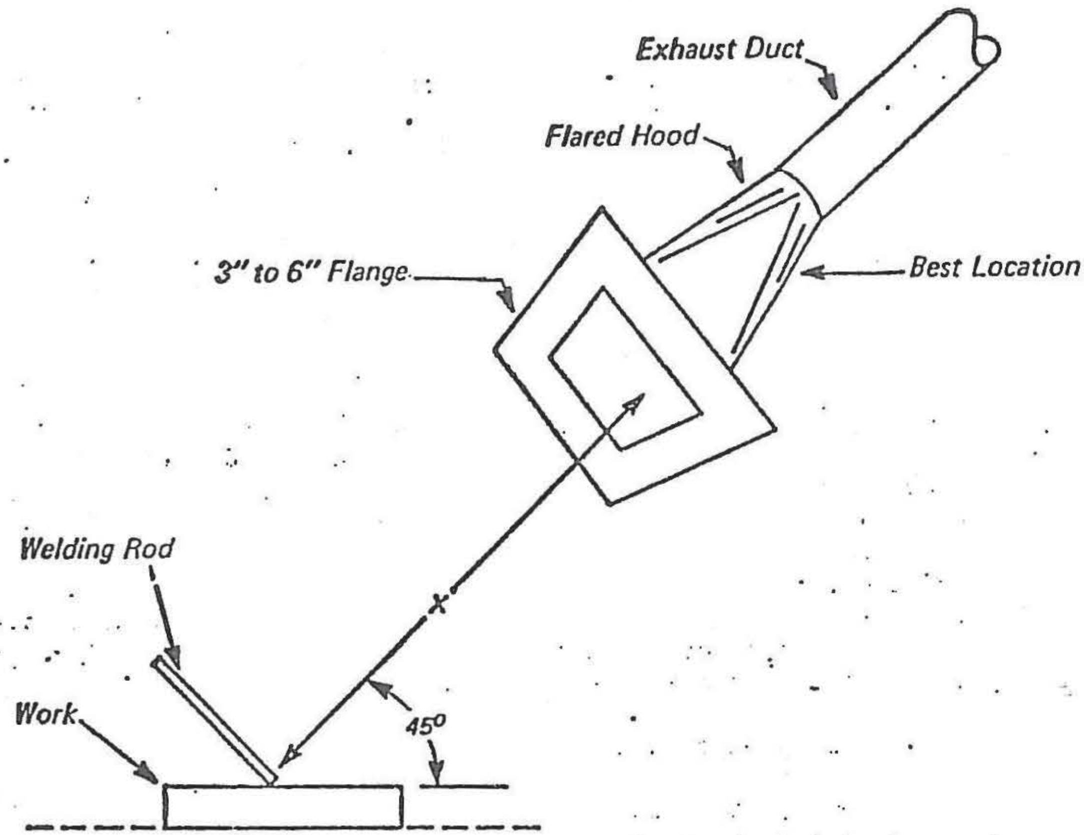
APPENDIX A
TABLE IV
GENERAL MACHINE SHOP WELDING SHOP
GENERAL AREA EXPOSURE DATA
NOVEMBER 14, 1979, FIRST SHIFT

Time Weighted Averages ($mg/m^3$)

| Area Sampler Location | Chromium | Iron | Manganese | Nickel | Lead | Hexavalent Chromium | $NO_2$ | NO |
|---|---|---|---|---|---|---|---|---|
| 1 | 0.008 | 0.319 | 0.047 | 0.002 | 0.004 | | 0.3 | 0.1 |
| 2 | 0.015 | 0.379 | 0.046 | 0.003 | 0.002 | | 0.3 | LLQ(2) |
| 5 | 0.012 | 0.332 | 0.033 | 0.002 | 0.002 | | 0.3 | LLQ |
| 6 | 0.015 | 0.297 | 0.025 | 0.002 | 0.001 | LLD(5) | 0.2 | LLQ |
| 8 | 0.010 | 0.509 | 0.030 | 0.003 | 0.003 | | 0.2 | LLQ |
| Evaluation Criteria | 0.5[3] | 5.0[3] | 1.0[3] | 0.015[4] | 0.1[4] | 0.001[4] | C1.8[4] | 30[4] |

(1) See Appendix A, Shop Layout
(2) Less than the Limit of Quantitation
(3) 1980 ACGIH recommended TLV
(4) NIOSH recommended health standard
(5) Less than the Limit of Detection

Appendix B, Figure 1




$$Q = K(10x^2 + A)V_x$$

$Q$ = exhaust volume, cfm

$X$ = distance from center of hood face to farthest point of contaminant release, ft

$A$ = hood face area (not including flange), sq ft

$V_x$ = minimum capture velocity, fpm

$K$ = 1.0 for unflanged hood; 0.75 for flanged hood

Entry loss = entry loss factor for tapered hood X duct VP

Duct velocity = 2000 fpm minimum

Freely Suspended Local Exhaust Hood

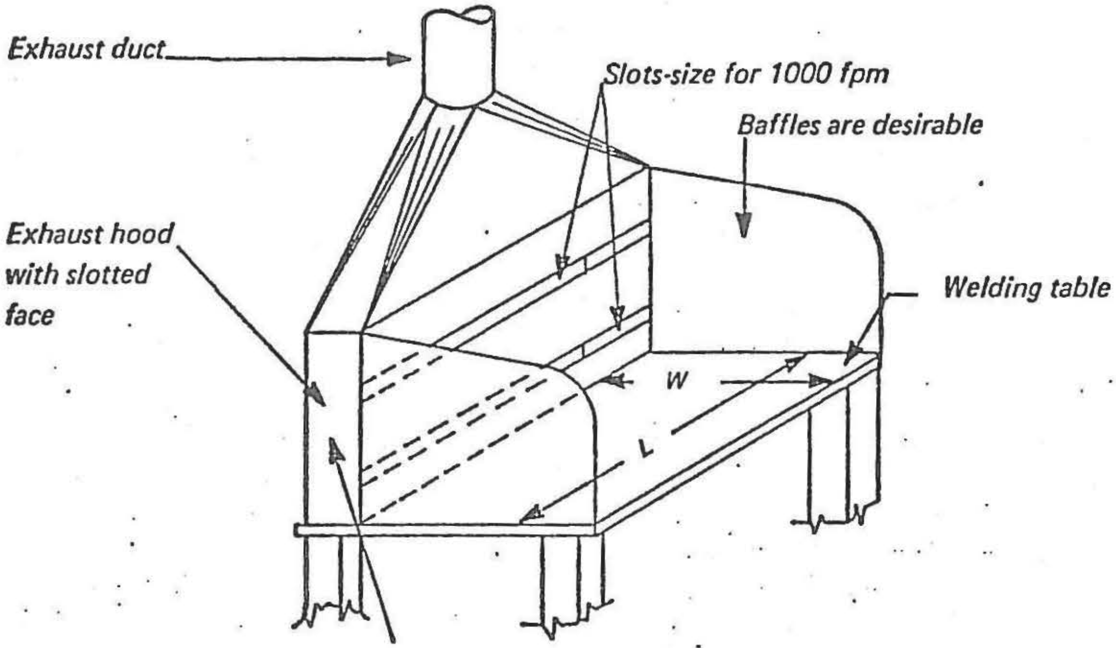
APPENDIX A
TABLE VI
GENERAL MACHINE SHOP WELDING SHOP
GENERAL AREA EXPOSURE DATA
NOVEMBER 15, 1979, SECOND SHIFT

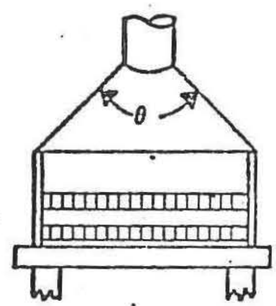
Time Weighted Averages (mg/m$^3$)

| Area Sampler Location(1) | Chromium | Iron | Manganese | Nickel | Lead |
|---|---|---|---|---|---|
| 7 | LLQ[2] | .230 | 0.009 | LLQ | 0.002 |
| Evaluation Criteria | 0.5[3] | 5.0[3] | 1.0[3] | 0.015[4] | 0.1 |

(1) See Appendix A, Shop Layout
(2) Less than the Limit of Quantitation
(3) 1980 ACGIH recommended TLV
(4) NIOSH recommended health standard

Appendix B, Figure 3



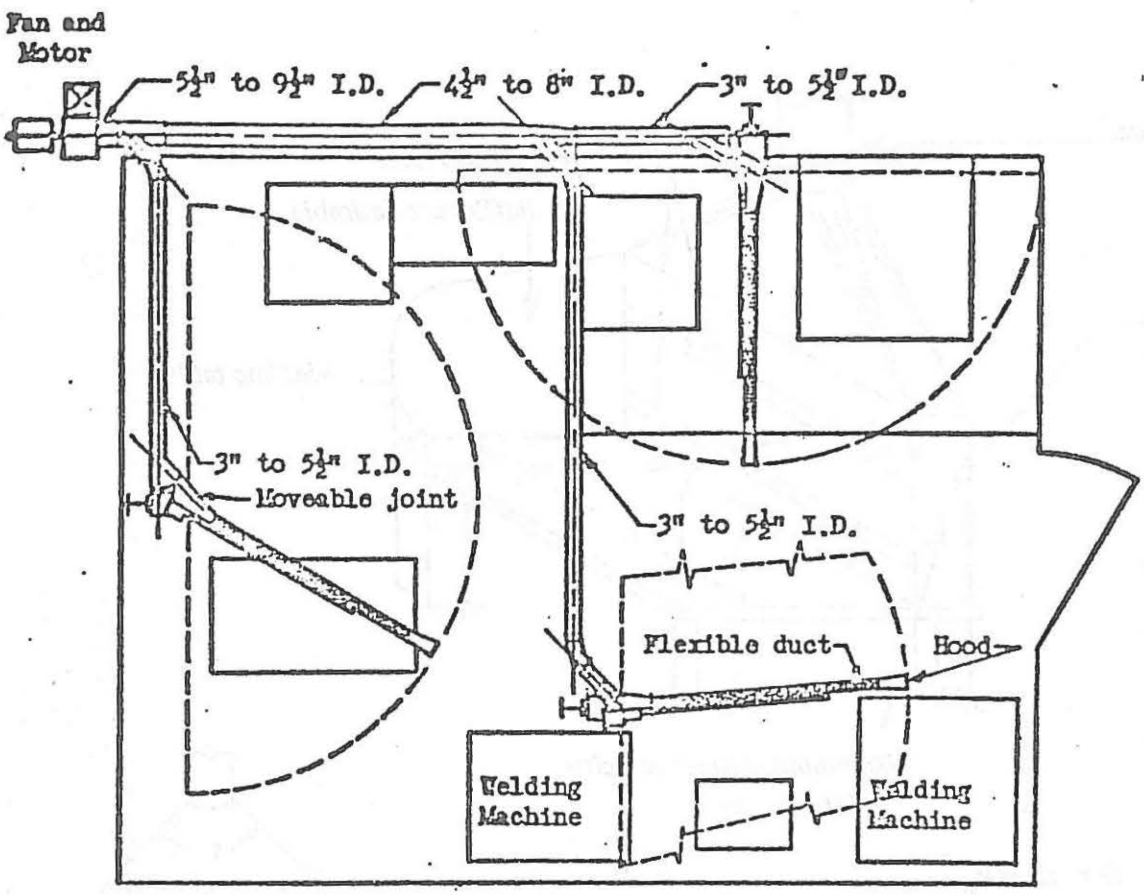




$$Q = KLWV_x$$

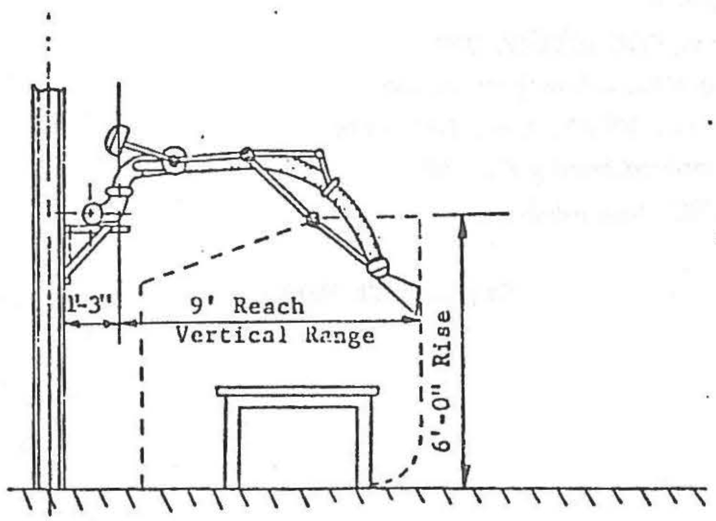
$Q$ = exhaust volume, cfm
$W$ = table width, ft (not to exceed 4 ft)
$L$ = table length, ft
$V_x$ = minimum capture velocity, fpm
$K$ = 2.4 with baffles; 2.8 without baffles
Entry loss = 1.78 slot VP plus entry loss factor for tapered hood x duct VP
Duct velocity = 2000 fpm minimum

Crossdraft Table

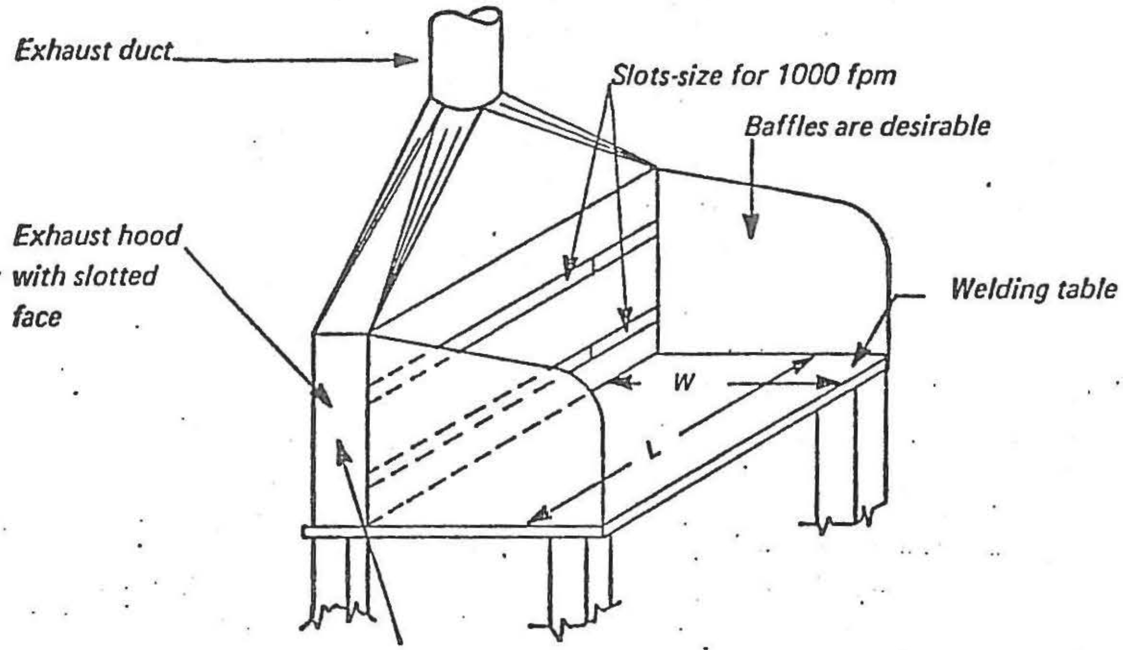
Appendix B, Figure 2

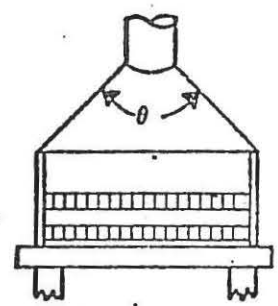



Typical Layout for Three Branch System




WELDING FUME EXHAUST UNIT



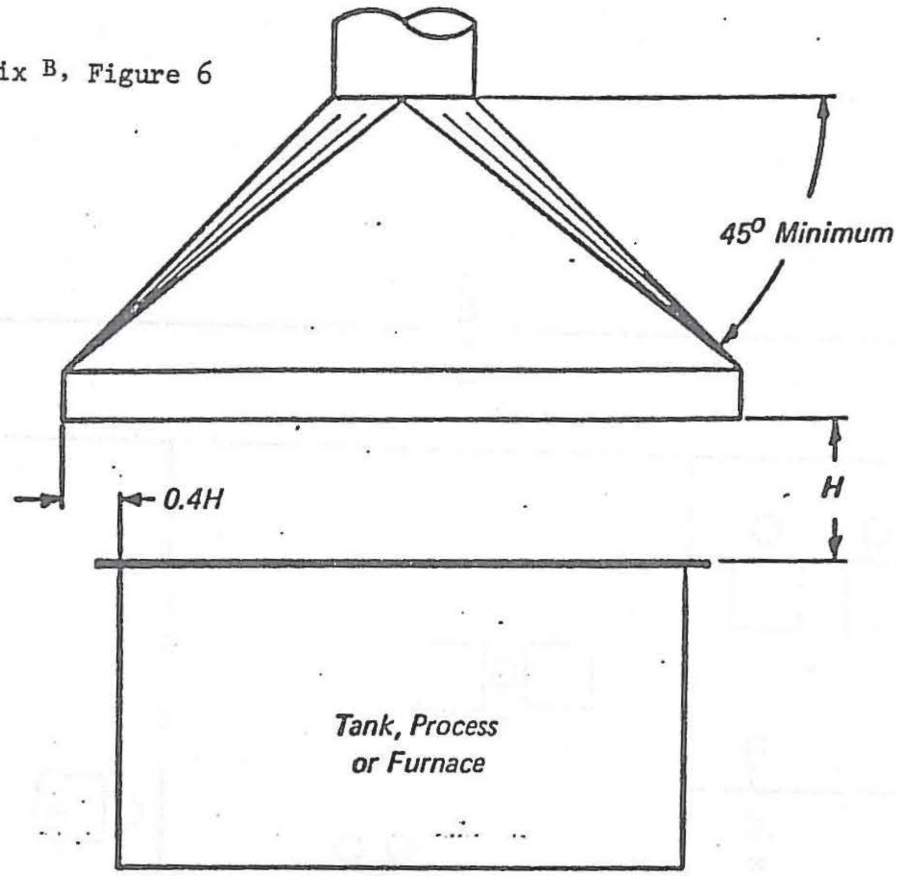




$Q = KLWV_x$

$Q$ = exhaust volume, cfm
$W$ = table width, ft (not to exceed 4 ft)
$L$ = table length, ft
$V_x$ = minimum capture velocity, fpm
$K$ = 2.4 with baffles; 2.8 without baffles
Entry loss = 1.78 slot VP plus entry loss factor for tapered hood x duct VP
Duct velocity = 2000 fpm minimum

Crossdraft Table

Appendix B, Figure 6




*Not to be used for Class A operations. Hood shall be curtained or baffled as necessary to ensure that crossdrafts do not cause excessive spillage of contaminants from canopy.*

*Q = exhaust volume, cfm*
*= 1.4 PHV* for open type canopy.
*P = perimeter of tank, feet*
*H = distance from lower edge of canopy to top of tank or process, feet*
*V = minimum capture velocity, fpm (See Table 3)*

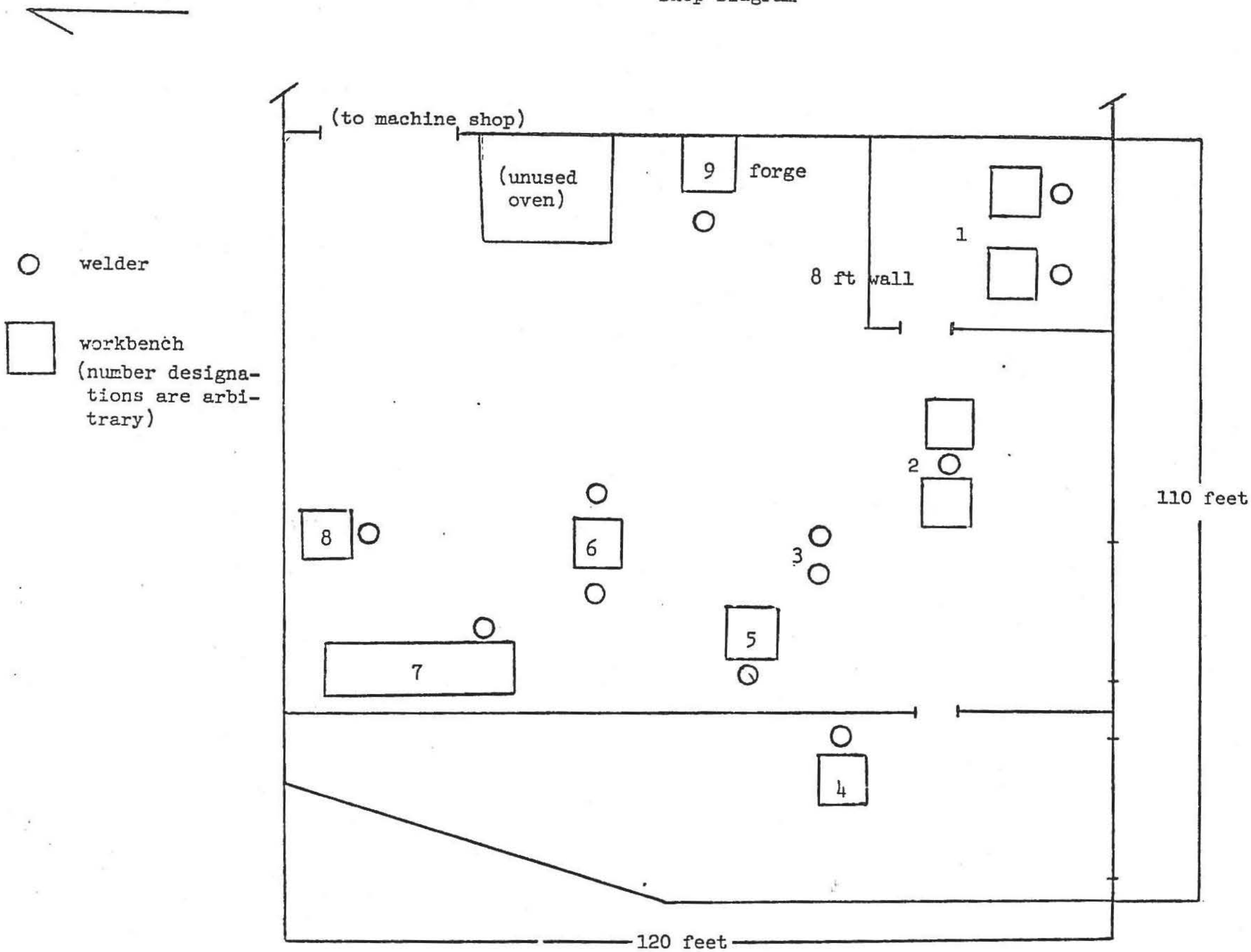
$Q = (P_o)HV$ for three sides open
$P_o$ = length of open sides of hood, feet $= 2L+W$ or $2W+L$
*W & L are open sides of hood, feet*
*V = minimum capture velocity, fpm (See Table 3)*

*Entry loss = entry loss factor for tapered hood X duct VP*
*Duct velocity = 1500 fpm minimum*

CANOPY HOOD

Appendix C

Shop Diagram




(ceiling - approx. 30 feet)