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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. 76-16-336

ABEX CORPORATION
PUEBLO, COLORADO

OCTOBER 1976

I. TOXICITY DETERMINATION

An evaluation of employee exposure to air contaminants generated during fabrication of ferromanganese railroad track products has been completed at the Abex Corporation, Pueblo, Colorado. National Institute for Occupational Safety and Health (NIOSH) investigators made visits to the facility on April 4-5 and June 21-22, 1976. Exposures of the grinders to manganese and nuisance aerosols, and welders to metallic oxides (manganese, vanadium and iron) and gaseous air contaminants (ozone and nitrogen dioxide) where evaluated. The following determinations have been made with regard to these substances affecting employee health:

1. The grinders concomitant exposure to manganese and nuisance aerosols were less than 13 and 85% of the evaluation criteria, respectively. Based upon the (a) normal neurological findings, (b) review of toxicological literature, and (c) relatively low concentrations of manganese measured, it is determined that these workers were not exposed to toxic concentrations of manganese under the conditions studied. Based upon the (a) health questionnaire response, (b) available literature on the toxicity of nuisance aerosols, and (c) environmental measurements, it is also determined that the respective workers were not exposed to excessive concentrations of nuisance particulates under the conditions studied.

2. The welders concurrent exposure to manganese and vanadium fumes, and ozone and nitrogen dioxide gases, were less than 21% of the evaluation criteria. The levels of iron oxide fume reported for the welders actual exposure period averaged 72% of the evaluation standard; however, calculated as an 8-hour T.W.A. it was reduced to 33.2%. Based upon the (a) normal neurological findings relative to manganese, (b) health questionnaire response, (c) available toxicological literature on these substances, and (d) environmental measurements, it is determined that the welders were not exposed to toxic concentrations of these substances under the conditions studied.

Section VI of this report offers recommendations for (a) further environmental control; (b) a supplement to the existing annual medical examination concerning manganism screening; and (c) institution of a respiratory protection program.

II. DISTRIBUTION AND AVAILABILITY OF DETERMINATION REPORT

Copies of this Determination Report are available upon request from the National Institute for Occupational Safety and Health (NIOSH), Division of Technical Services, Information Resources and Dissemination Section, 4676 Columbia Parkway, Cincinnati, Ohio 45226. Copies have been sent to:

a) Abex Corporation, Pueblo, Colorado
b) Authorized Representative of the United Steel Workers of America (USWA)-Local Union No. 3405, Pueblo, Colorado
c) U.S. Department of Labor - OSHA - Region VIII
d) NIOSH - Region - VIII

III. INTRODUCTION

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

The National Institute for Occupational Safety and Health received such a request from an authorized representative of USWA-Local Union No. 3405 regarding exposure to (1) manganese particulate and fugitive dust generated during grinding of manganese alloy and mild steel castings by grinder-assemblers on the manganese floor, (2) metallic oxides and gaseous air contaminants produced during repair and assembly work of railroad track products by welders, and (3) noise resulting from abrasive wheel grinding activities by grinder-assemblers. Worker exposure to the physical agent (noise) was not evaluated because it falls outside the authorities of Section 20(a)(6), which is directed exclusively at chemical agents, unless a synergistic or combined effect is suspected to occur from concurrent exposure to the chemical and physical agents. Such is not believed to be occurring with the agents under investigation.

IV. HEALTH HAZARD EVALUATION

A. Process Description and Associated Potential Health Hazards

This facility is involved in the fabrication of railroad trackwork including switch points, and various types of crossings and frogs. Each track product contains a manganese alloy casting of about 12% elemental manganese. The percent (by weight) of the manganese alloy casting in the finished product varies with each type of track product. For example, the percent of the alloy casting contained in a solid crossing is around 63, in contrast to 17% in an average reversible crossing. The manufacturing process involves drilling, machining, grinding, fettling and assembling of steel and manganese alloy castings into a final track product.

The health hazard evaluation request is directed at (1) grinding, fettling and assembly operations on the manganese floor and (2) reconstructive and assembly welding in the welding department.

The manganese floor is an area loosely delineated by work stations for different types of railroad track products. Approximately 16 grinder-assemblers (8 per shift) conduct light grinding of castings with electric hand grinders. After the casting components are ground to a specific fit, they are assembled into a finished product. Of which, some products such as frogs, may require additional grinding of the manganese component. This is accomplished by 2 planar-surface grinders, operating two shifts and requiring one person per grinder. The grinder-assemblers and surface-planars are potentially exposed 8-hours per day, five days per week to manganese dust. Also, they are exposed to other particulates classed with the group of industrial dusts which are regarded as "nuisance aerosols." In contrast to fibrogenic dusts which produce nodular or diffuse lesions in the lungs when inhaled in excessive amounts, "nuisance dusts" have a long history of little adverse effect on lungs and do not produce significant organic disease or toxic effect when exposures are kept under reasonable control.[1]

Manganese alloy casting repair work known as "surface manganese build-up" and general assembly welding is conducted by a welder. "Surface manganese build-up" is defined as build-up of a damaged or improper surface of a manganese casting to a certain specification by the deposition of manganese supplied by a welding rod electrode. The base metals contained in the electrode include about 17 and 0.5% elemental manganese and vanadium, respectively. General assembly involves standard electric-arc welding of mild steel mounting plates to the under surface of frogs. Considering the composition of alloys being welded, type of welding, and chemical composition of electrodes used, two welders (one per shift) are potentially exposed to metallic oxides (manganese, vanadium and iron) and gaseous air contaminants (ozone and nitrogen dioxide).

B. Evaluation Design

On March 3-5, 1976, an initial environmental study survey was conducted at the plant by a team of NIOSH industrial hygienists. An entrance interview was conducted with representatives of management and labor to obtain background information about processes, materials, work schedules, and employee profile. Subsequent to the briefing, a walk-through orientation was conducted of the manganese floor and welding department to establish a study protocol. Manganese and nuisance aerosol concentrations were measured at the breathing zone of grinder-assemblers, and manganese, vanadium pentoxide, iron oxide, ozone and nitrogen dioxide at the breathing zone of a welder. An attempt was made to use urinary manganese as a second index of evaluating worker exposure to manganese. However, after further review of the literature,[2,3] which showed that this was not a reliable indicator of toxicity or absorption, this attempt was abandoned. Persons with signs and symptoms suggestive of manganese intoxication do not necessarily have elevated urinary manganese levels, and persons exposed to high concentrations do not necessarily have symptoms or high urinary manganese concentrations.

Because several of the medical questionnaires completed on the affected workers educed that a few persons had some physical complaints which may have been related to their exposure to manganese, a medical evaluation was conducted on June 21 and 22, 1976. The evaluation consisted of completing a neurological screening examination for manganism (manganese poisoning) on 75% of the exposed workers.

C. Evaluation Methodology

1. Environmental Evaluation Methods

a. Metals and Nuisance Aerosols: Welder exposure to oxides of manganese, vanadium and iron were evaluated by having the welder wear a helmet modified to provide a breathing zone measurement of these contaminants inside the mask.[4] Significantly higher contaminant concentrations outside the welding helmet than inside have been reported.[5] The grinder-assemblers and surface-planars exposure to manganese and nuisance aerosols were evaluated by placing a sampling port at the workers breathing zone.

The metals were concurrently collected on a 0.8 micrometer (μm) pore size mixed cellulose ester filter and total aerosols on a tared 5.0 μm pore size polyvinyl chloride filter; each was mounted in a 3-piece closed face cassette. A vacuum pump maintained a flowrate of 1.5 lpm through the respective sampling mediums (flow volumes were corrected for changes in atmospheric pressure and temperature). Metal concentrations were determined by wet ashing the filters in nitric acid and analyzing by atomic absorption spectrophotometry.[6] The lower limit of analytical detection reported for manganese, vanadium pentoxide and iron oxide was 0.001, 0.005 and 0.005 mg substance per filter, respectively. The nuisance aerosol concentrations were determined gravimetrically, i.e. by weight increase..

b. Ozone:[7] The rubber-cracking method was used to quantitate the levels of ozone generated during welding. The procedure consists of exposing uniform unvulcanized and stretched rubber to ozone and quantitating the ozone concentration by determining the number and depth of cracks in a given area by optical examination. Standarized strips of rubber 1.5 inches by 0.25 inch folded in the middle with the ends secured together to produce reproducible tension were mounted inside the welders helmet. The strips were exposed for 4 and 8 hours.

c. Nitrogen Dioxide:[8] Welder exposure to nitrogen dioxide was estimated with direct reading NIOSH certified Drager gas detector tubes (Certification No. TC-84-050). A certified tube must have $\pm$ 35% accuracy at 1/2 the exposure limit and $\pm$ 25% at 1 to 5 times the limit.

2. Medical Evaluation Methods

Health questionnaires were completed on 13 of approximately 20 affected workers on March 4 and 5, 1976. A non-directed questionnaire was completed in order to elicit any symptoms or medical problems that came spontaneously to mind. A subsequent directed questionnaire was completed only if the response to the former indicated a need for more specific questions. A physician elicited clarification of these questionnaires was performed on 75% of the exposed workers from both the first and second shifts on June 21 and 22, 1976. An employee health questionnaire (Table I) which included possible symptoms and signs of manganism and a neurological screening examination using the symptoms and signs contained in the respective table were completed.

D. Evaluation Study Criteria

1. Criteria for Assessing Workroom Concentrations of Air Contaminants

The source of environmental evaluation criteria is the Recommended and Proposed Threshold Limit Values (TLVs) and Their Supporting Documentation as set forth by the American Conference of Governmental Industrial Hygienists (ACGIH), 1975. These recommendations are based on the most current state of knowledge concerning the toxicity of these substances and are designed to protect individuals occupationally exposed to these substances on an 8-hour per day, 40 hours per work week basis over a normal working lifetime. The TLVs are time-weighted averages (TWA) for an 8-hour exposure, except when preceded by C, which indicates a ceiling value that should never be exceeded.

The environmental evaluation criteria are presented below with the corresponding OSHA standard footnoted. The occupational health standards promulgated by OSHA (Federal Register, July 1, 1975, Title 29, Part 1910, Subpart Z, Section .1000) applicable to the substances studied are presented only to provide management with a perspective of their existing state of compliance or non-compliance with Federal health regulations. Consequently, no discussion of their relationship to the contaminant levels measured will be offered.

	Workroom Environmental Criteria	
Substance	8-hr. T.W.A.	*Ceiling Value
[1]Manganese and compounds, as Mn		5 mg/m^3
[2]Vanadium (V_2O_5)		0.05 mg/m^3
[3]Iron oxide fume	5 mg/m^3	
[4]Ozone	0.1 ppm	
[5]Nitrogen dioxide		5 ppm
[6]Nuisance aerosols (Total particulate)	10 mg/m^3	

* Milligrams of substance per cubic meter of air sampled.
Parts of substance per million parts of air sampled.

[1]The Federal occupational health standard is 5 mg/m^3 expressed as a ceiling value.

[2]The Federal occupational health standard is p.1 mg/m^3 expressed as a ceiling value.

[3]The Federal occupational health standard is 10 mg/m^3 expressed as an 8-hour T.W.A.

[4]The Federal occupational health standard is 0.1 ppm expressed as a ceiling value.

[5]The Federal occupational health standard is 5 ppm expressed as a ceiling value.

[6]The Federal occupational health standard is 15 mg/m^3 expressed as an 8-hour T.W.A.

2. Medical Evaluation Criteria

The medical criteria used to determine a toxic response to the substances under investigation consist of symptoms and signs which each agent produces when a toxic exposure occurs. A brief review of the known pathophysiological effects of the substances and supplemental references follows:

a. Manganese:[1,2,3,9] Chronic manganese poisoning is primarily a disease of the central nervous system, so-called manganism--a Parkinsonism-like syndrome. Symptoms and signs include loss of appetite, sexual impotence, difficulty in urination, a peculiar slapping gait, weakness in doing heavy work, cramps or tremors of the body and extremities, a mask-like expression, impulsive and uncontrollable laughter, speech difficulty, hallucinations, insomia, absentmindedness, and mental confusion. Others are listed in Table I.

b. Vanadium (V_2O_5) as V fume:[1,10] The local effects are irritation to mucous membranes of eyes, nose, throat, and upper respiratory tract. Greenish discoloration of the tongue is common, but is of no known toxicologic significance. The systemic effects include pulmonary irritation and possibly pneumonitis; no specific chronic lung lesions have been described.

c. Iron Oxide Fume:[1] Excessive exposure to iron oxide fume may result in siderosis. Siderosis is a condition of the lungs caused by inhalation of iron oxide fume particles in the pulmonary tissues usually accompanied by discrete pigmentation. Although these changes are not considered to be associated with any physical disability, the pigmentation sometimes presents problems in differential diagnosis of other existing lung diseases.

d. Ozone:[1,11] Air concentrations of ozone in excess of a few tenths parts per million occasion discomfort to exposed persons in the form of headache, and dryness of throat and mucous membranes of nose and eyes following exposures of short duration. The primary site of acute injury is the lung which is characterized by pulmonary conjestion, edema and hemorrhage from severe exposures.

e. Nitrogen Dioxide:[1] Excessive exposures produce irritation to eyes and mucous membranes. Prolonged low-level exposure may produce yellowish tt to brown staining of the teeth and skin.

f. Nuisance Aerosols:[1] Inhalation of excessive amounts cause no adverse effects in the lung; elevated concentrations reduce visibility and may result in unpleasant deposits in the eyes and nose, plus injury to the mucous membranes through mechanical action.

V. RESULTS AND DISCUSSION

A. Environmental

The concentrations of manganese and total particulate measured at the breathing zone of one planar-surface grinder and seven grinder-assemblers are presented in Table II. The reported levels of maganese ranged from 0.04 to 0.63 mg/m^3 (0.17 mg/m3 average), which are less than 13% of the 5 mg/m^3 (ceiling value) TLV set forth by the ACGIH (1975). Total particulate concentrations were measured at the breathing zone of three randomly selected assembler-grinders. The reported levels ranged from 5.77 to 8.40 mg/m^3 (7.44 mg/m^3 average), which are less than 85% of the 10 mg/m^3 TLV. Though the total particulate levels measured were below the evaluation criteria, these measurements were made at only one point in time and may not reflect an occasional excrescence that may occur on other days such as Mondays and Tuesdays. According to the interviewed workers more grinding is usually conducted on these days compared to that on the days sampled when assembly work is primarily done. It is the opinion of this author, that the nuisance particulate levels generated from increased grinding could exceed the TLV for this substance; however, it appears doubtful that the manganese TLV would be exceeded. Based on the known lack of toxicological activity of nuisance particulates, NIOSH did not conduct a follow-up environmental survey to measure the exposure levels on such days.

The concentrations of manganese, vanadium pentoxide, and iron oxide fume, ozone and nitrogen dioxide generated during electric-arc welding of mild steel and manganese alloy castings were monitored at the breathing zone of a welder on March 4 and 5, 1976. The concentrations of ozone and the metallic oxides were measured inside the welders helmet; nitrogen dioxide levels were measured outside. In order to address the 5 mg/m^3 ceiling value for manganese, air sampling was only conducted during welding.

The airborne concentrations of the metallic oxides and ozone measured are contained in Tables III and IV, respectively. The levels of manganese ranged from 0.32 to 0.74 mg/m^3 (0.53 mg/m^3), which are less than 15% of the 5 mg/m^3 ceiling value. On both days, the levels of vanadium pentoxide were less than the limit of detection (F0.005 mg) of the analytical method used. The airborne levels of iron oxide fume reported for the "actual exposure periods" ranged from 2.50 to 4.60 mg/m^3 (3.60 mg/m^3 average), which are less than 93% of the 5 mg/m^3 TLV. The "actual exposure period" is the summation of the workers periods of exposure to welding emissions over the 8-hour workday. In view of this fact that air monitoring was only conducted during welding, the reported exposure levels would be significantly less when expressed as an 8-hour time-weight average. The concentrations calculated on an 8-hour time-weighted basis would be 1.01 and 2.30 mg/m^3, respectively, with an average exposure level of 1.66 mg/m^3. The concentrations of ozone measured were less than 20% of the 0.1 ppm TLV. No nitrogen dioxide was detected with colorimetric tubes.

B. Medical

A total of 15 workers (1 welder and 14 assembler-grinders) were interviewed and examined. This constituted 75% of the total workers (20 males) exposed. Their average age is 31.7 years (range 19 to 61, median 27) and the average length of working time in their present capacity is 6.2 years (range 1 to 17, median 5).

1. Review of Symptoms

There were nine (9/15) employees who had no health complaints. The remaining six workers had single complaints of backache, headache, nasal conjestion, or tightness in the chest. These were mostly of mild to moderate degree of severity and may or may not be related to their job. For example, one person stated that his nose became conjested when he reported to work, which suggests the possible presence of an allergy to some industrial contaminant.

Two workers had backache, one as a result of a motorcycle accident, and the other thought to be due to his body positioning on the job. One person who had difficulty breathing was considered to have been suffering from an anxiety reaction--hyperventilation syndrome. None of the above symptoms were considered to be related to their exposure to manganese.

2. Neurological Signs

Nine workers had an essentially negative neurological examination. Six workers had a single positive neurological sign such as slightly increased or diminished patellar reflexes or faint tremor of tongue or fingers. (These 9 negative and 6 positive signs did not necessarily match those 9 negatives and 6 positives in symptomatology. There appeared to be no pattern of correlation). Each of these single signs, by itself, was not considered significant. There were no examinees who had muscular rigidity or incoordination, micrographia, spastic gait, or other gait disturbance.

VI. SUMMARY AND CONCLUSIONS

The processes and associated potential health hazards pursuant to Health Hazard Evaluation Request No. 76-16 have been studied by NIOSH during investigations conducted on April 4-5 and June 21-22, 1976. Grinder-assemblers and planar-surface grinders exposures to manganese and nuisance particulates, and welders exposures to metallic oxides (manganese, vanadium and iron) and gaseous (ozone and nitrogen dioxide) air contaminants were evaluated and assessed.

The grinder-operators concurrent exposure to manganese and nuisance aerosols were less than 13 and 85% of the recommended TLVs, respectively. Based upon the (1) normal neurological findings, (2) review of toxicological literature, and (3) relatively low concentrations of manganese measured, it is determined that the grinder-operators were not exposed to toxic concentrations of this substance under the conditions studied. Based upon the (1) health questionnaire response, (2) available literature on the toxicity of nuisance aerosols, and (3) environmental measurements, it is also concluded that the respective workers were not exposed to excessive concentrations of nuisance aerosols under the conditions studied.

The welders concurrent exposure to manganese and vanadium fumes, ozone and nitrogen dioxide gases, were less than 21% of the recommended TLVs. The levels of iron oxide fume reported for the welders actual exposure period averaged 72% of the recommended TLV; however, calculated as an 8-hour T.W.A. it was reduced to 33.2%. Based upon the (1) normal neurological findings relative to manganese, (2) health questionnaire response, (3) available literature on the toxicity of these substances, and (4) environmental measurements, it is determined that the welders were not exposed to toxic concentrations of these substances under the conditions studied.

Section VI of this report offers recommendations for (1) further control of particulate and/or gaseous air contaminants generated at the hand grinding and electric-arc welding stations; (2) a supplement to the existing annual medical examination relative to manganism screening; and (3) institution of a respiratory protection program.

VII. RECOMMENDATIONS

A. Environmental

The proceeding recommendations for control of particulate generated from the grinding stations, and fumes and gases during welding are patterned after those contained in the Industrial Ventilation Manual published by the ACGIH.[12] Specific design considerations follow; however, it should be realized that these illustrations and associated criteria are intended as guides for design purposes and apply to typical operations

1. Though the particulate concentrations measured on the manganese floor did not exceed the environmental evaluation criteria used in this study, the reported levels indicate a real potential for such an occurrence. The following mechanisms may be applicable to reducing the particulate levels. Equipping the grinding wheels (radial and cone) and cutting tools (pneumatic chisel) with low-volume-high-velocity (L-V-H-V) exhaust systems. Illustrations and associated design criteria are contained in Figures 1,2,3, and 4. A L-V-H-V system may be defined as the application of exhaust which uses small volumes of air at relatively high velocities. Control is achieved by exhausting the air directly at the point of dust generation using close-fitting-custom made hoods.

2. The measured levels of the welding emissions during this survey did not exceed their respective TLVs; however, in view of the toxicologic activity of manganese and vanadium pentoxide fumes and nitrogen dioxide and ozone gases, it recommended that local exhaust ventilation be installed. Due to the nature of the welders job which involves work on very large castings, a direct capture hood suspended from an over-head mono-rail system may be most feasible. The exhaust duct should be constructed of a flexible material (e.g., flexible ventilation duct) to permit hood repositioning. An illustration of a freely suspended hood and associated design criteria are illustrated in Figure 5.

B. Medical

1. Although this evaluation found generally low levels of atmospheric manganese and workers to be neurologically within normal limits, there is a potential danger of contracting manganism where high manganese alloys are fabricated.[13] Therefore, the present program of annual medical examination should be continued and supplemented with a neurological evaluation of signs and symptoms for manganism.

2. Employees exposed to manganese should be informed of the potential hazard of manganism by management and be instructed to report to their personal or company physician should they experience some of the symptoms listed in Table I.

C. Respiratory Protection

On April 4 and 5, 1976, several assembler-grinders were observed wearing respirators while grinding metal castings. Pursuant to Part 1910.134 (b) of the U.S. Department of Labor (OSHA) Code of Federal Regulations (CFR), it is recommended that a written respirator program meeting the outlined eleven criteria for a "minimal acceptable program" be prepared.

1. Respirators used should be those certified under the NIOSH respirator standards, 30 CFR, Part 11.

2. Respirators should be issued with caution. There might be individuals in this group for whom wearing a respirator carries certain specific dangers, i.e., highly increased resistance to airflow in a person with compromised pulmonary function may be associated with acute respiratory insufficiency. Therefore, pulmonary function testing should be carried out prior to requiring any person to wear a respirator.

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TABLE I

ITEMS FOR MANGANISM SCREENING

Abex Corporation
Pueblo, Colorado

Date ______________________________

Name ______________________________

Company ______________________________

SYMPTOMS

1. Unusual weakness or tiredness
2. Loss of appetite
3. Cannot sleep well at night or unusual sleepiness
4. Irritability or mood change
5. Frequent and unusual headache
6. Unusual muscle pains and/or cramps
7. Sexual impotence
8. Clumsy or sluggish movement
9. Difficulty in talking (stuttering or slurring)
10. Shaky fingers or hands
11. Difficulty in walking or unable to walk backward
12. Difficutly in urination

SIGNS

1. Irritable/agressive
2. Monotonous speech
3. Stuttering/slurring
4. Mask-like face
5. Micrographia
6. Tremor
7. Impulsive laughter/weeping
8. Spastic gait
9. Propulsion
10. Retropulsion
11. Quick/sharp turn
12. Sit-stand up without use of hand
13. Cogwheel resistance
14. Deep tendon reflexes
15. Clonus
16. Babinski
17. Adiadokokinesis
18. Mystagmus
19. Paresthesia

TABLE II

BREATHING ZONE MANGANESE AND TOTAL PARTICULATE CONCENTRATIONS PRODUCED DURING GRINDING AND/OR ASSEMBLY OF RAILROAD TRACK PRODUCTS

Abex Corporation
Pueblo, Colorado

March 4 and 5, 1976

Date Collected	Job Classification	Sampling Period	Sample Volume Liters	*Measured Air Concentrations-mg/m^3 Manganese	**Total Particulate
3-4	Assembler-Grinder	0615-1155	680	0.40	8.13
3-4	Assembler-Grinder	0618-1148			
		1230-1358	836	0.03	5.77
3-4	Assembler-Grinder	0625-1151			
		1240-1407	826	0.06	**
3-4	Assembler-Grinder	0626-1153			
		1242-1408	826	0.29	8.40
3-4	Assembler-Grinder	0628-1152			
		1241-1404	814	0.10	**
3-4	Planar-Grinder	0623-1150			
		1236-1400	822	0.11	**
3-5	Assembler-Grinder	0637-1159			
		1243-1335	748	0.03	**
3-5	Assembler-Grinder	0617-1154			
		1245-1337	778	0.31	**
3-5	Assembler-Grinder	0618-1155			
		1238-1338	794	0.07	**
3-5	Assembler-Grinder	0621-1159			
		1241-1340	794	0.20	**
3-5	Assembler-Grinder	0620-1158			
		1240-1340	796	0.03	**
3-5	Assembler-Grinder	0614-1152			
		1237-1340	802	0.04	**
3-5	Assembler-Grinder	0624-1152			
		1238-1340	780	0.04	**
3-5	Planar-Grinder	0615-1156			
		1235-1343	818	0.10	**

*Mg/m^3: Milligrams of contaminant per cubic meter of air sampled.

**No gravimetric determination was made.

TABLE III

MEASUREMENT OF METALLIC OXIDE CONCENTRATIONS
PRODUCED DURING ELECTRIC ARC WELDING

Abex Corporation
Pueblo, Colorado

March 4 and 5, 1976

Sampling Time Hours	Sample Volume Liters	*Metallic Oxide Concentrations-mg/m^3		
		Manganese	Vanadium	Iron
3.07	368	0.32	<0.005	2.60
3.98	477	0.74	<0.005	4.60

aminant per cubic meter of air sampled.

TABLE IV

CONCENTRATIONS OF OZONE
PRODUCED DURING ELECTRIC ARC WELDING OF RAILROAD TRACK PRODUCTS

Abex Corporation
Pueblo, Colorado

March 4 and 5, 1976

Date COLLECTED	TYPE OF SAMPLE	JOB CLASSIFICATION	SAMPLING TIME HOURS	*OZONE CONCENTRATIONS
3-4-76	Personal	Welder	4	<.02
3-4-76	Personal	Welder	4	<.02
3-4-76	Personal	Welder	8	<.01
3-5-76	Personal	Welder	4	<.02
3-5-76	Personal	Welder	8	<.01

* ppm: Parts of contaminant per million parts of air sampled.

Figure 1

Hood Design and Associated Criteria
For
Cup Type Surface Grinders and Wire Brushes[12]

Abex Corporation
Pueblo, Colorado

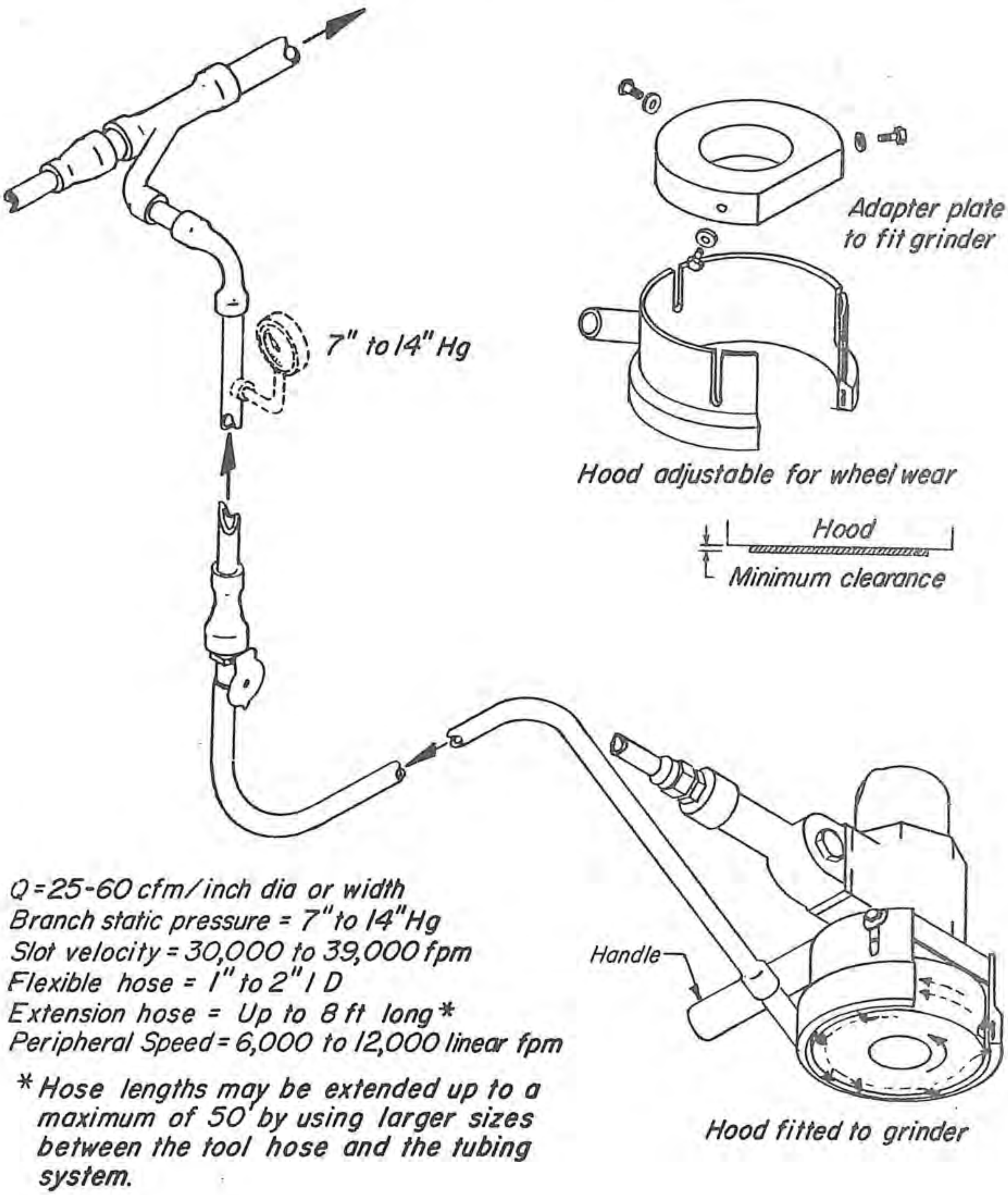


Figure 2

Extractor Head for Cone Wheels
and
Mounted Points[12]

Abex Corporation
Pueblo, Colorado

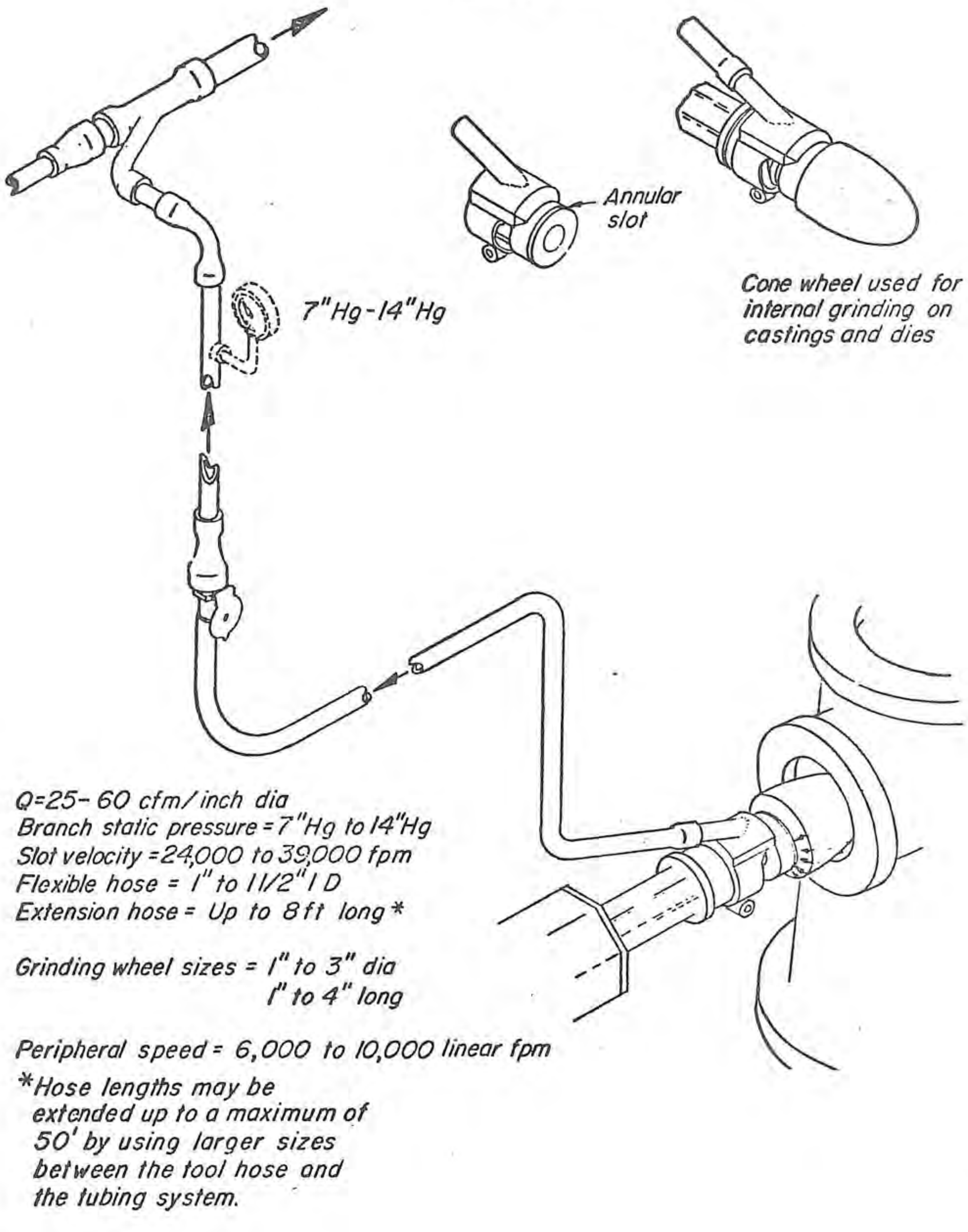


Figure 3

Design Criteria for a Pneumatic Chisel Sleeve[12]

Abex Corporation
Pueblo, Colorado

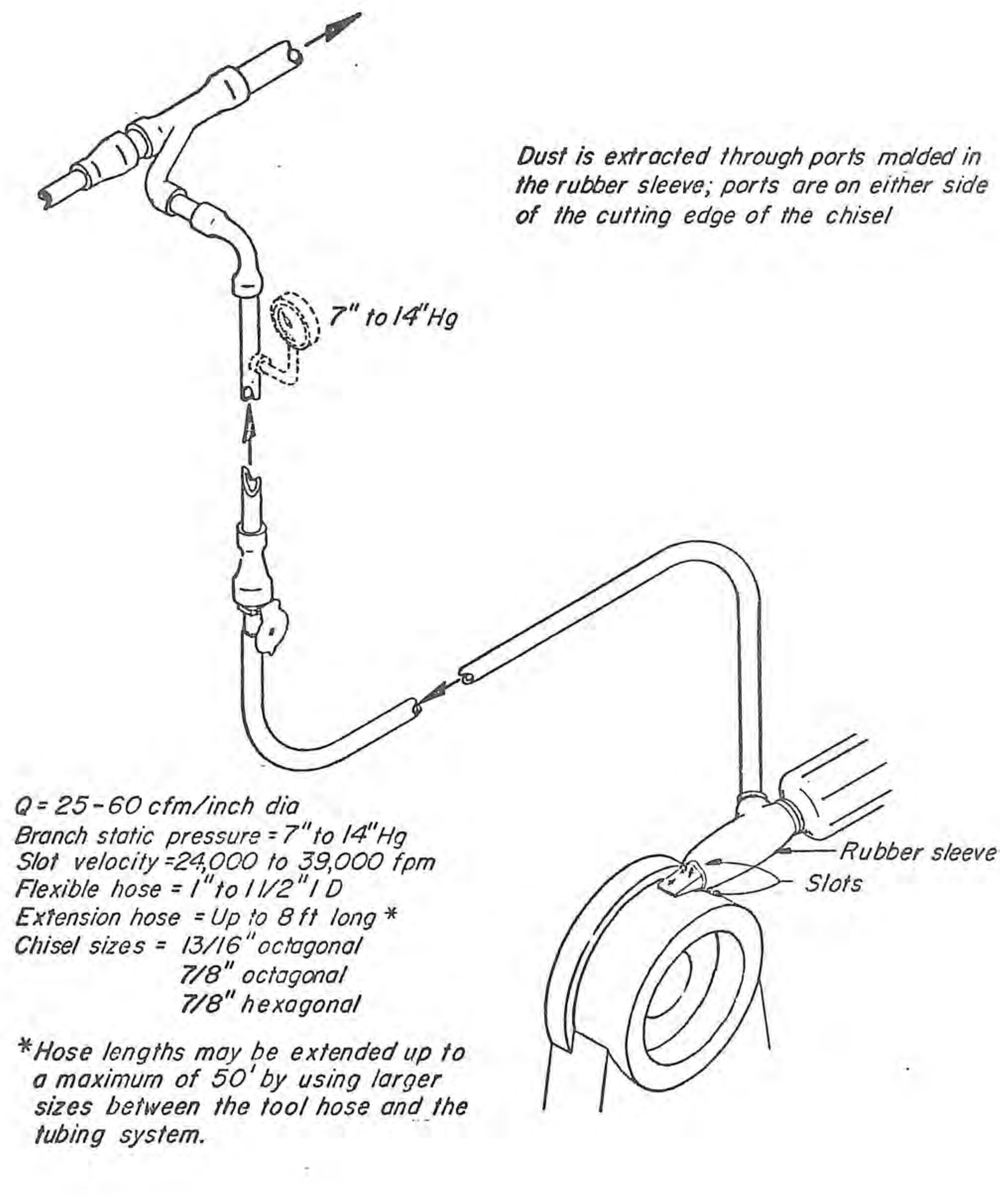


Figure 4

Hood Design and Associated Criteria
For
Small Radial Grinders

Abex Corporation
Pueblo, Colorado

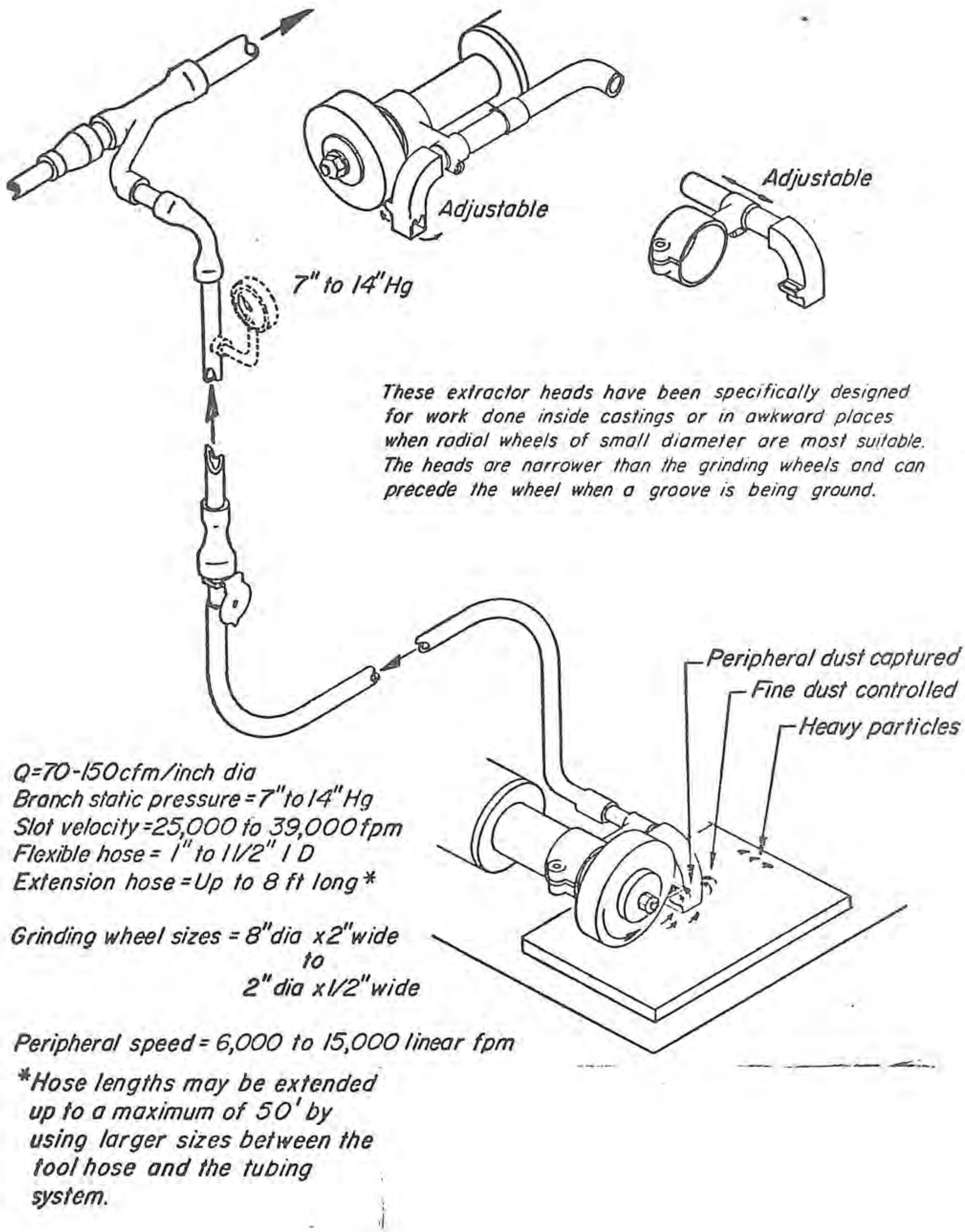
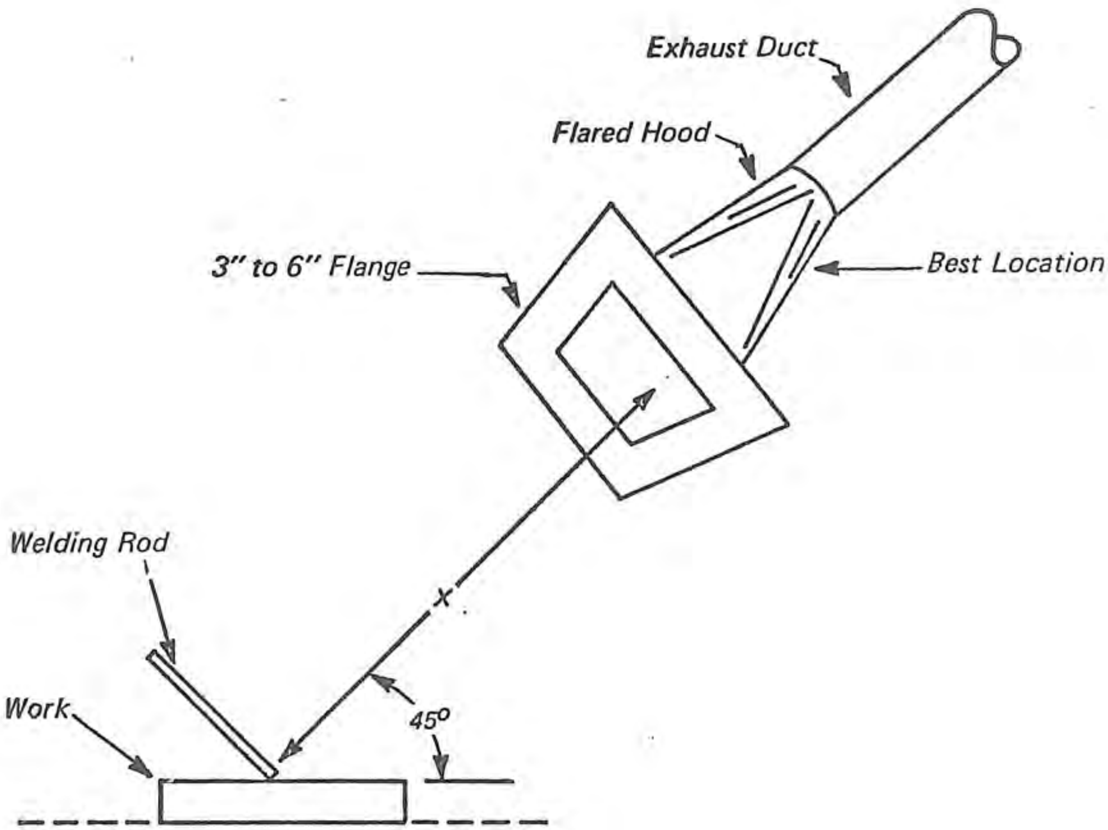


Figure 5

Hood Design and Associated Criteria
for an
Freely-Suspended Open Hood

Abex Corporation
Pueblo, Colorado



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

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