IN-DEPTH SURVEY REPORT.

HIGH-VELOCITY LOW-VOLUME EXHAUST OF MANUAL SANDING OPERATIONS

AT

NAVISTAR, COLUMBUS PLASTICS PLANT
COLUMBUS, OHIO

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PLANT SURVEYED:	Navistar Columbus Plastics Plant 800 Manor Park Drive Columbus, Ohio 43228
SIC CODE	3713 (Truck and Bus Bodies)
SURVEY DATES	April 13 - 15, 1987 April 20 - 22, 1987
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I INTRODUCTION

The National Institute for Occupational Safety and Health (NIOSH) is the primary Federal agency engaged in occupational safety and health research Located in the Department of Health and Human Services (formerly the Department of Health, Education, and Welfare), it was established by the Occupational Safety and Health Act of 1970 This legislation mandated NIOSH to conduct a number of research and education programs separate from the standard setting and enforcement functions conducted by the Occupational Safety and Health Administration (OSHA) in the Department of Labor. An important area of NIOSH research deals with methods for controlling occupational exposure to potential chemical and physical hazards The Engineering Control Technology Branch (ECTB) of the Division of Physical Sciences and Engineering has been given the lead within NIOSH to study the engineering aspects of hazard control

Since 1976, ECTB has conducted a number of assessments of health hazard control technology on the basis of industry, common industrial process, or specific control techniques The objective of each of these studies has been to document and evaluate effective control techniques for potential health hazards in the industry or process of interest, and to create a more general awareness of the need for or availability of an effective system of hazard control measures

This report concerns an evaluation of dust controls for hand-held sanders and routers at the Columbus Plastics Plant of Navistar (formerly the International Harvester Company) This report is a follow-up to an earlier walk-through survey (ECTB Report 146-16) conducted to evaluate control measures for styrene exposures in the sheet molding compound (SMC) process.[1] In that report it was noted that the SMC process appeared to present less of an exposure hazard to styrene than the hand lay-up of fibrous glass reinforced plastic parts It was also noted that one problem area that the SMC process shares with other reinforced plastics processes is the potentially high exposure to fibrous glass and plastic dusts from the extensive manual trimming and finishing operations A program to develop dust controls for small tools such as saws, drills, grinders, and sanders was recommended to the plant at that time

In early 1987 Mr. Mark Skryzpek, the present plant manager of the Columbus Plastics Plant, informed members of the ECTB staff of his desire to test the use of certain tool-mounted, high-velocity, low-volume (HVLV) exhaust hoods He made arrangements with a distributor of this equipment to temporarily install (one week) a system on a sander and a router, and requested the assistance of NIOSH in the evaluation of its effectiveness This report concerns that evaluation

II PLANT AND PROCESS DESCRIPTION

Plant description

The Columbus Plastics plant produces truck hood and fender assemblies, truck air deflector assemblies, vehicle air conditioner cases, and small parts used in Navistar trucks in addition to automobile fascias for a major automobile manufacturer The plant was purchased by Navistar from Rockwell about six years ago

Process description

All parts are manufactured using the SMC process In this process, a thickened (with calcium carbonate) styrene/polyester resin is combined with chopped glass and sandwiched between sheets of plastic film The resulting mat is allowed to age at 80°F. At the presses, the mat is rough cut and the film is removed After hand trimming to the desired shape, the mat is molded and cured in a steam heated press When removed from the press, the parts are trimmed, cut, and sanded as necessary They are prime coated prior to shipment A schematic diagram of the process is included in Reference 1

Teams of two workers each perform finish sanding and repairs to the truck hoods One worker will proceed to the press room to load a hood assembly on a dolly and roll it to the sanding station Both workers begin sanding the edges of the hood assembly with 100 grit abrasive paper using an air operated orbital finishing sander Small imperfections are then repaired with a lacquer-type body putty. Larger holes are repaired with a two-part polyester resin/peroxide catalyst body filler The entire outside hood surface is then sanded with 180 grit abrasive paper using the same sanders The hoods are periodically blown clean with compressed air The part is then rolled to a conveyor to which it is manually transferred Each team prepares 39 hood assemblies per day Actual sanding time amounts to approximately 6 to 7 minutes per hood A layout of the process area is shown in the Appendix as Figure A-1.

Two workers assemble approximately 32 air deflectors per day. Air deflectors are removed from a storage rack and mounted in a fixture Two holes, each measuring approximately 8 cm by 20 cm are cut using an air operated router The cuts are guided by use of a jig After cutting, stiffening ribs are added to the deflector using a two component adhesive and clamping until the adhesive cures

Exposure controls

Occupational exposures can be controlled by the application of a number of well-known principles, including engineering measures, ventilation, work practices, personal protection, and monitoring

Engineering measures--
Compressed air exhausts from two of the sanders (both located at the station studied) were equipped on an experimental basis with a rubber hose to exhaust tool air at ceiling height This trial was underway to reduce tool noise and prevent the entrainment of sanding dust by the exhaust stream A high-velocity low-volume hood and portable blower/dust collector was obtained by the plant on trial from the manufacturer (Dustcontrol Environmental Systems, Waterford, MI) The plant provided a sander and router to the hood manufacturer, who then fabricated hoods for each tool The sander which was outfitted with the hood had a conventional compressed air exhaust

Ventilation--
No local exhaust was used for the purpose of removing fibrous glass dust from sanding and trimming operations Local exhaust ventilation was used in the sheet molding compound production area to remove styrene vapors Pedestal fans directed at the workers were used to provide cooling near the heated presses and at the sanding areas

Work practices--
The workers engaged in routing the air deflector assembly constructed a cardboard shield which deflected the router's stream of air and grinding detritus away from their faces The deflector consisted of one-half of a cardboard box which was notched so that it could be hung from the fixture holding the air deflector No other work practices were observed which would result in either an increase or decrease in exposure

Personal protection--
Disposable dust masks were provided to the workers About half used these respirators, but only while they were sanding

Monitoring--
Industrial hygiene monitoring is conducted on an as-needed basis by the Navistar corporate industrial hygienist.

III POTENTIAL HAZARDS AND EXPOSURE GUIDELINES

As a guide to the evaluation of the hazards posed by workplace exposures, NIOSH field staff employ environmental evaluation criteria for the assessment of a number of chemical and physical agents These criteria are intended to suggest levels of exposure to which most workers may be exposed up to 10 hours per day, 40 hours per week for a working lifetime without experiencing adverse health effects. It is, however, important to note that not all workers will be protected from adverse health effects if their exposures are maintained below these levels A small percentage may experience adverse health effects because of individual susceptibility, a preexisting medical condition, and/or a hypersensitivity (allergy).

The primary sources of environmental evaluation criteria for the workplace are. 1) NIOSH recommended exposure limits (REL's), 2) the American Conference of Governmental Industrial Hygienists' (ACGIH) Threshold Limit Values (TLV's), and 3) the U.S Department of Labor (OSHA) permissible exposure limits (PEL's) Often, the NIOSH REL's and ACGIH TLV's are lower than the corresponding OSHA PEL's. Both NIOSH REL's and ACGIH TLV's usually are based on more recent information than are the OSHA PEL's The OSHA PEL's also may be required to take into account the feasibility of controlling exposures in various industries where the agents are used; the NIOSH REL's, by contrast, are based primarily on concerns relating to the prevention of occupational disease In evaluating the exposure levels and the recommendations for reducing these levels found in this report, it should be noted that industry is legally required to meet only those levels specified by an OSHA PEL Atime-weighted average (TWA) exposure refers to the average airborne concentration of a substance during a normal 8- to 10-hour workday Some substances have recommended short-term exposure limits or ceiling values which are intended to supplement the TWA where there are recognized toxic effects from high short-term exposures

Dust consisting of fibrous glass in a matrix of polyester resin would appear to be the major hazard in the manual trimming and finishing of the molded products. The health effects that have been observed from exposure to fibrous glass include skin, eye, and upper respiratory tract irritation, a relatively low frequency of fibrotic changes, and a very slight indication of an excess mortality risk due to nonmalignant respiratory disease. Fibrous glass is considered to be a nuisance dust by both the American Conference of Governmental Industrial Hygienists[2] and the Occupational Safety and Health Administration.[3] The ACGIH has assigned a Threshold Limit Value (TLV) of 10 mg/m^3 for fibrous glass. The OSHA PEL for inert or nuisance dust is 15 mg/m^3 for total dust, 5 mg/m^3 for the respirable size fraction. Much of the concern about fibrous glass results from similarities with asbestos. Fibrous glass has been shown to have different biologic effects based on particle (fiber) size. NIOSH, recognizing that "fibrous glass is not an inert dust yet, it is not as hazardous as asbestos," recommends a two-part environmental limit: 1) 3 fibers/cc of air having a diameter equal to or less than 3.5 micrometers, and a length equal to or greater than 10 micrometers, 2) 5 mg/m^3 for total dust. Both limits are TWA concentrations.[4]

IV. METHODOLOGY

A two-week study was conducted at this plant. Air sampling was conducted during the week of April 13 to obtain baseline dust exposure data for the sander and router operators. After installation of HVLV hoods on one sander and one router, air sampling was again conducted during the week of April 20. Measurements of the air flow generated by the rotating sander and router were made before and after installation of the HVLV hoods.

Integrated air sampling

Worker exposures to total dust were determined for one router and two sander operators. Background concentrations were measured in two locations in the vicinity of each of the workstations to determine the degree of cross-contamination from other dust producing operations in the area. Total dust sampling was conducted using preweighed FWSB filters and DuPont P4000 pumps operated at 2.5 lpm. Two 4-hour samples were collected on each of 3 days for each operator and location during the first week. Because the HVLV apparatus was available for only one sander and due to a variety of production difficulties, a smaller number of samples were collected during the second week. The HVLV hood supplied for the router did not permit use of the production jig, therefore the router portion of the study was terminated.

In addition to the samples for total dust, 3 samples of varying duration (10, 30, 60 minutes) were collected on AA filters using DuPont P4000 pumps operated at 2.5 lpm on the sander and the router operators. The sander operator fiber exposure was determined both with and without the use of the HVLV hood. These samples were analyzed by microscopy (light and/or transmission electron microscopy (TEM)) for size analysis of fibers.

Real-time air sampling

Each operator also was studied using a hand-held aerosol monitor (HAM) connected to a data logger (Rustrak Ranger) and his/her activities videotaped Data from the data logger was downloaded to a portable computer for analysis The HAM is a device which indirectly measures the quantity of airborne dust by determining the amount of light scattered by dust particles The measured level is a function of the optical properties of the specific dust The instrument is calibrated by comparing the instrument output signal, integrated over a given time period, to a measurement obtained by conventional (filter) techniques over the same time period This determines the instrument's response or calibration factor

During the first week the real-time instruments were used in parallel with the personal sample for total dust on the sander and router operators Individual sampling periods of approximately one hour each were collected over a single four hour filter sampling period During the second survey, the router operator was not sampled, due to the inability of the hood to fit the router mentioned earlier During this survey, one instrument was used to sample a worker's dust exposure while using a hooded sander, a second was used for a worker using an uncontrolled sander

Airflow Measurements

The air velocity and direction around the sander were determined using a hot wire anemometer and smoke tubes under two conditions 1) the sander with no hood, free-running, and held in space, 2) the sander with the hood, not running, and resting on a flat surface. The purpose of these measurements was to determine the maximum air velocities that could be induced by the spinning sander These air currents can potentially transport the freshly generated sanding debris into the breathing zone of the worker. These induced air currents must be overcome by the exhaust hood to effect control.

V RESULTS

Integrated air sampling

Results of individual measurements of personal exposures and background concentrations of total dust are reported in Table A-1 in the Appendix and summarized in Table I The workers are engaged in essentially the same tasks for the entire work shift Thus, the 8 or 10 hour time-weighted exposures would be similar to the short-term (2 - 4 hour) exposure results shown in Table I

The average exposure of the router operator to fibrous glass was above that recommended by NIOSH These exposures were highly variable, 2 of the 5 samples above 10 mg/m^3, and 3 well below 3 mg/m^3. Because of the remote location of this operation relative to other dust sources, the routing was most certainly the cause The background concentrations were low in this area, averaging 0.45 mg/m^3, indicating that the dust generation was localized to the routing operation

Table I   Summary of measurements of total airborne dust.

Worker/Location	Number of Samples	Concentration (mg/m3) Average	Std Deviation
Router operator	5	6.22	6.17
Background-router area	6	0.45	0.34
Sander operator (uncontrolled tool)	9	2.48	1.20
Sander operator (hooded tool)	3	0.96	0.11
Background-press room	8	1.09	0.55
Background-sander area	6	0.65	0.39

All of the exposures of the sander operators were below the NIOSH recommended level. The exposures of the operators using the sanders equipped with the HVLV hoods were significantly lower than those of the workers using the uncontrolled tools (95% confidence level). These data indicate that nearly all the exposure of the workers using the hooded tools was due to the background contamination. The hood nearly eliminated the worker's own sander as an exposure source - dust contaminating his breathing zone was from other sanding operations in the area. These results are limited by the small number of samples and any effects due to different workers. Background concentrations were slightly higher in the press room than at the location monitored in the sanding area, which had in turn, higher dust levels than the general workroom concentrations measured in the router area.

Fiber analysis of the collected air samples was unsuccessful. Manual sizing by TEM was found to be impractical because the material deposited on the microscope grid as agglomerates rather than as individual particles. The size of the agglomerates ranged in diameter from <1 um to >75 um. A second attempt was made to perform a particle size distribution using the Magiscan (a phase contrast microscope equipped with an automated image analysis system. This approach failed because the particles were transparent, resulting in a halo effect around the agglomerates caused by light refracted by the particles. This effect prevented the attainment of the proper gray image necessary for the particle size program to distinguish individual particles.

Real-time air sampling

Real time exposure data was collected for two workers, one using the HVLV hood equipped sander, the other using the uncontrolled tool. Real-time air sampling plots are presented in Figures A2 - A5 in the appendix. Since the work task is repetitive, two segments were analyzed, one 20 minutes long (the time required to sand 2 hood assemblies) and the other ten minutes long. The pedestal fan was "off" during the first segment and "on" during the second. The exposure data (for each 3 seconds of the work segments) were transferred to a spreadsheet for analysis Video tapes were reviewed and activity variables were assigned to each exposure datum The activity variable "sanding" was assigned the value "1" if the worker was sanding during the three second interval, "0" if he/she was not The activity variable "blowing" was assigned the value "1" if the worker was cleaning the hood assembly surface with compressed air during the three second interval, "0" if he/she was not. If both "sanding" and "blowing" had the value "0" then the worker activity was described as "other" Activities falling into this class included waiting for hood assemblies, moving unfinished or finished products, and preparing repair compounds (body filler)

Using these variables the average concentration for the activities "sanding", "blowing", and "other" were calculated and presented in Table II for both workers and both conditions (pedestal fan "off" and "on"). The relative importance of each activity was ascertained by calculating the concentration-time product, or pseudo-dose. For three of the four conditions, "other" activities represent the greatest dust dose Since none of the "other" activities involve dust generating activities, this dose is due to cross-contamination from other workers sanding in the vicinity If the average dust concentration during "other" activities is subtracted from the average concentration during "sanding", then the contribution of that workers own "sanding" activities can be measured, and the results compared for the hood equipped and uncontrolled tools. The results of these calculations are presented in Table II The hood resulted in a 64 percent decrease when the pedestal fan was "off" and a 100 percent decrease when the fan was "on"

Data analysis

The real time data do not consists of simple sets of independent measurements. Each data point may be some function of the preceding measurements. To determine if the effect of the hood was real, or simply an accidental observation, both the data sets "fan on" and "fan off" were subjected to the statistical analysis described in the Appendix For the data set "fan on" the hood was found to have a statistically significant beneficial effect The effect of the hood for the data set "fan off" was inconclusive. Apparently dust exposures were occurring in this data set not associated with the observed activities While not definitive, the real time data were consistent with the integrated sampling, indicating that the sander hood did reduce exposure. Accurate estimation of the degree of reduction would take further study.

Airflow Measurements

The air velocity and direction around the sander determined using a hot wire anemometer and smoke tubes with the sander with no hood, free-running, and held in space are depicted in Figures A-6 and A-7 The uncontrolled sander acts like a centrifugal fan air is pulled toward the center of the disc, is given rotation by the disc, and propelled away from the edge of the disc at approximately 1200 fpm. The hood functions to overcome these induced velocities. Air velocities with the hood in place are shown in Figure A-8

VI. DISCUSSION

Since the majority of the exposure of the two workers studied is not directly related to their own work activity, why should any controls for the sanding operation be considered? Table II indicates that the exposure of both workers doubles when the pedestal fan is "off" These fans effectively dilute the dust created during sanding Unfortunately, they do not remove the dusty air from the work area, but disperse it among all the workers, effectively raising
Table II. Analysis of real time sampling data for the sanding operators
the background concentration for all. Plant wide installation of hooded tools would result in not only the reducing dust exposure produced by the individual workers own activities, but would reduce cross-contamination, thereby lowering dust exposures for all workers

The main function of the pedestal fans is worker cooling The sanding operation is carried out under a storage mezzanine next to the press room Heat from the press room as well as heat released from the freshly molded hood assemblies contributes to the workers' heat load. While the pedestal fans serve to cool the workers, they are counterproductive to dust control The area is currently not supplied with fresh air nor is any exhaust ventilation present

Blowing dust off the hood assembly did not appear to result in an appreciable dust dose to the two workers studied, "blowing" representing from 2 to 8 percent of the total dose. It can be seen from viewing the video tapes that visible clouds of dust are blown away from the workers Thus, although the two workers took care not to blow dust at each other, their activities certainly increased the exposure of others Use of the compressed air nozzles not only removed dust from the hood assembly, but re-entrained dust that had settled to the floor

VII CONCLUSIONS AND RECOMMENDATIONS

The highest dust exposures (and the only above the NIOSH REL for fibrous glass) were for the routing operation on the air deflector assembly Unfortunately the HVLV hood supplied was incompatible with the jig used for locating the holes, so no control evaluation was possible It is hoped that the supplier of the hoods can work out a compatible design

HVLV hoods for the sanding operations demonstrated an exposure reduction effect Real-time sampling results indicate potential reductions of 64 to 100 percent Integrated sampling results indicate reductions of the same magnitude. These numbers are crude estimates, better estimates would require the installation of more hoods and operations studied on an off-shift to avoid problems of cross contamination from other dust producing operations While the results were not definitive, they are encouraging The plant should seriously consider installation Any installation plan should examine ease of use. Care needs to be taken so that undue strain is not placed upon the workers from the additional tool weight. The tool lines (compressed air, compressed air exhaust, and dust control exhaust) should be counterbalanced

Table II Analysis of real time sampling data for the sanding operators

Pedestal fan OFF

	Uncontrolled Sander				Hooded Sander			
Activity	Time sec	Dose mg/m3-s	%	Conc mg/m3	Time sec	Dose mg/m3-s	%	Conc mg/m3
Sanding	381	1333	52	3 5	306	574	32	1 9
Blowing	48	55	2	1.1	60	134	8	2 2
Other	912	1157	45	1 3	975	1063	60	1 1
Total	1341	2545	100	1 9	1341	1772	100	1 3
AVG SANDING CONCENTRATION.				3 5				1 9
AVG CONCENTRATION DURING "OTHER" ACTIVITIES.				1 3				1 1
AVG DIFFERENCE				2 2				0 8
PERCENT REDUCTION (due to hood).								64%

Pedestal fan ON

	Uncontrolled Sander				Hooded Sander			
Activity	Time sec	Dose mg/m3-s	%	Conc. mg/m3	Time sec	Dose mg/m3-s	%	Conc. mg/m3
Sanding	213	289	43	1.4	195	218	37	1 1
Blowing	18	23	3	1.3	21	27	5	1 3
Other	306	368	54	1.2	321	347	59	1.1
Total	537	679	100	1.3	537	592	100	1 1
AVG SANDING CONCENTRATION				1.4				1 1
AVG CONCENTRATION DURING "OTHER" ACTIVITIES.				1 2				1.1
AVG DIFFERENCE.				0.2				0.0
PERCENT REDUCTION (due to hood).								100%

Three concentric lines (compressed air within tool exhaust within dust exhaust) may eliminate torque placed upon the tool by the lines A training program may be necessary to ensure worker acceptance and proper maintenance

The plant should establish goals to eliminate the use of the pedestal fans to minimize cross-contamination in the plant Worker cooling through the use of pedestal fans can thwart dust control efforts Introduction of fresh air by means of fixed showers of low velocity air located above each work area might offer a solution

There is no easy alternative to the use of compressed air to clean freshly sanded parts Perhaps the use of hooded tools will remove at least some of the adherent dust Limiting the compressed air pressure may minimize dust re-entrainment from the floor Vacuuming the surface of the hood assembly may be a possibility though it would surely take longer and may not provide a clean enough surface for subsequent painting The best solution may be to wipe the surface with a wet sponge. Perhaps even the sanding could be performed wet. Obviously provisions would need to be made to drain excess water in order to provide safe footing for the workers

VIII. REFERENCES

1 O'Brien, D. M , and W. F. Todd. Control Technology for New Materials at International Harvester, Columbus Plastics Plant National Institute for Occupational Safety and Health. Engineering Control Technology Branch (ECTB) Report No. 148-16. Cincinnati, Ohio. National Institute for Occupational Safety and Health, 1984

2. American Conference of Governmental Industrial Hygienists Threshold limit values for chemical substances and physical agents in the workroom environment and biological exposure indices with intended changes for 1984-85 Cincinnati, Ohio ACGIH, 1984

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4. National Institute for Occupational Safety and Health. Criteria for a recommended standard. occupational exposure to fibrous glass Cincinnati, Ohio. National Institute for Occupational Safety and Health, 1977 (DHEW publication no. (NIOSH) 77-152)

APPENDIX

Table A-1. Total dust (fibrous glass) measurements.

NAVISTAR, COLUMBUS PLASTICS PLANT KEY

S SANDER	BG BACKGROUND	0 OFF or ABSENT
R ROUTER	1 ON or PRESENT	BK BLANK

S/R	OPER	FAN	HOOD	JOB TITLE	SAMPLE TYPE	DATE	PUMP	FILTER	FLOW (l/m)	START TIME	STOP TIME	RUN TIME	VOLUME (l)	MASS (ug)	BLANK CORR (ug)	CONC (mg/m3)
R	1	0	0	AIR DEFL ASSMBLR	DUST	13-Apr-87	6378	8350	2 51	12 52 PM	03 04 PM	02 12	331 32	540	527	1 591
R	BG	0	0	COLUMN D6	DUST	13-Apr-87	6382	8351	2 5	12 57 PM	03 01 PM	02 04	310	120	107	0 345
R	BG	0	0	COLUMN C7	DUST	13-Apr-87	5515	8355	2 49	12:59 PM	02 59 PM	02 00	298 8	50	37	0 124
S	2	0	0	PREPPER	DUST	13-Apr-87	5520	8335	2 5	09-25 AM	11 48 AM	02 23	357 5	1550	1537	4 299
S	3	0	0	PREPPER	DUST	13-Apr-87	5515	8338	2 49	09 33 AM	11 49 AM	02 16	338 64	1130	1117	3 298
S	BG	0	0	COLUMN E2	DUST	13-Apr-87	6382	8334	2 5	09-37 AM	11-57 AM	02 20	350	200	187	0 534
S	BG	0	0	INSIDE PRESS ROOM	DUST	13-Apr-87	6378	8343	2 51	09.38 AM	11.56 AM	02 18	346 38	620	607	1 752
R	BK				DUST	13-Apr-87		8354		12-52 PM	12-52 PM	00-00		-10		
R	BK				DUST	13-Apr-87		8347		12 52 PM	12 52 PM	00 00	0	110		
S	BK				DUST	13-Apr-87		8339		12 52 PM	12 52 PM	00 00	0	20		
R	1	1	0	AIR DEFL ASSMBLR	DUST	14-Apr-87	4900	8333	2 5	08 22 AM	11 50 AM	03 28	520	8080	8067	15 513
S	3	1	0	PREPPER	DUST	14-Apr-87	5515	8346	2.49	08.26 AM	11.55 AM	03.29	520.41	2010	1997	3 837
R	BG	1	0	COLUMN C7	DUST	14-Apr-87	5750	8337	2 5	08 22 AM	11 49 AM	03 27	517 5	610	597	1 154
S	BG	1	0	INSIDE PRESS ROOM	DUST	14-Apr-87	6382	8345	2 5	08 28 AM	11 53 AM	03 25	512 5	220	207	0 404
R	1	1	0	AIR DEFL ASSMBLR	DUST	14-Apr-87	4900	8353	2 5	12 32 PM	03-17 PM	02 45	412 5	4860	4847	11 750
S	3	1	0	PREPPER	DUST	14-Apr-87	5515	8336	2 49	12 36 PM	03 13 PM	02 37	390 93	1140	1127	2 883
R	BG	1	0	COLUMN C7	DUST	14-Apr-87	5750	8349	2 5	12 30 PM	03 16 PM	02 46	415	230	217	0 523
S	BG	1	0	INSIDE PRESS ROOM	DUST	14-Apr-87	6382	8332	2 5	12 34 PM	03 13 PM	02 39	397 5	110	97	0 244
R	BK				DUST	14-Apr-87		8341		12 52 PM	12 52 PM	00 00	0	0		
S	BK				DUST	14-Apr-87		8344		12 52 PM	12 52 PM	00 00	0	0		
R	1	1	0	AIR DEFL ASSMBLR	DUST	15-Apr-87	5870	8348	2 49	08 19 AM	11 47 AM	03 28	517 92	490	477	0 921
R	BG	1	0	COLUMN C7	DUST	15-Apr-87	5750	7384	2 5	08 18 AM	11 48 AM	03 30	525	110	97	0 185
S	2	1	0	PREPPER	DUST	15-Apr-87	5515	8352	2.49	08 26 AM	11 52 AM	03 26	512 94	470	457	0 891
S	BG	1	0	COLUMN E2	DUST	15-Apr-87	4900	7389	2 5	08 23 AM	11 54 AM	03 31	527 5	560	547	1 037
S	BG	1	0	INSIDE PRESS ROOM	DUST	15-Apr-87	6382	7393	2 5	08 26 AM	11 54 AM	03 28	520	710	697	1 340
R	1	1	0	AIR DEFL ASSMBLR	DUST	15-Apr-87	5820	7394	2 49	12.38 PM	03 15 PM	02 37	390 93	540	527	1 348
S	2	1	0	PREPPER	DUST	15-Apr-87	5515	7597	2 49	12-40 PM	03 09 PM	02.29	371 01	1090	1077	2 903
R	BG	1	0	COLUMN C7	DUST	15-Apr-87	5750	7390	2 5	12 35 PM	03 13 PM	02 38	395	160	147	0 372
S	BG	1	0	COLUMN E2	DUST	15-Apr-87	4900	7386	2 5	12 41 PM	03 07 PM	02 26	365	290	277	0 759
S	BG	1	0	INSIDE PRESS ROOM	DUST	15-Apr-87	6382	7596	2 5	12 43 PM	03 06 PM	02 23	357 5	630	617	1 726
S	BK				DUST	15-Apr-87		7536		12 45 PM	12 45 PM	00 00	0	-10		
S	2	0	1	PREPPER	DUST	20-Apr-87	5515	8457	2 5	09 12 AM	11 48 AM	02 36	390	420	407	1 044
S	3	0	0	PREPPER	DUST	20-Apr-87	6307	8462	2 5	09:17 AM	11 47 AM	02 30	375	740	727	1 939
S	BG	0	0	COLUMN E2	DUST	20-Apr-87	6378	8459	2 5	09 22 AM	11 50 AM	02 28	370	100	87	0 235
S	BG	0	0	INSIDE PRESS ROOM	DUST	20-Apr-87	6391	8456	2 5	09 22 AM	11 51 AM	02-29	372 5	540	527	1 415
S	5	0	1	PREPPER	DUST	22-Apr-87	14396	8261	2 5	11 12 AM	12 00 PM	00 48	120	110	97	0 808
S	5	0	1	PREPPER	DUST	22-Apr-87	6378	8469	2 5	01 24 PM	03 04 PM	01 40	250	270	257	1.028
S	4	0	0	PREPPER	DUST	22-Apr-87	14610	8265	2 5	11 12 AM	12 00 PM	00 48	120	190	177	1 475
S	4	0	0	PREPPER	DUST	22-Apr-87	14610	8475	2 5	01 24 PM	03 04 PM	01 40	250	210	197	0 788
S	BK				DUST	22-Apr-87		8460					0	-10		
S	BK				DUST	22-Apr-87		8472					0	50		
S	BK				DUST	22-Apr-87		8478					0	-20		
S	BK				DUST	22-Apr-87		8465					0	0		
S	BG	0	0	COLUMN E2	DUST	22-Apr-87	6307	8264	2 5	11 12 AM	12 03 PM	00 51	127 5	30	17	0 133
S	BG	0	0	COLUMN E2	DUST	22-Apr-87	6307	8461	2 5	01 30 PM	03 29 PM	01 59	297 5	370	357	1 200
S	BG	0	0	INSIDE PRESS ROOM	DUST	22-Apr-87	14399	8257	2 5	11.12 AM	12 03 PM	00 51	127 5	160	147	1 153
S	BG	0	0	INSIDE PRESS ROOM	DUST	22-Apr-87	14399	8463	2 5	01:30 PM	03 29 PM	01 59	297 5	210	197	0 662

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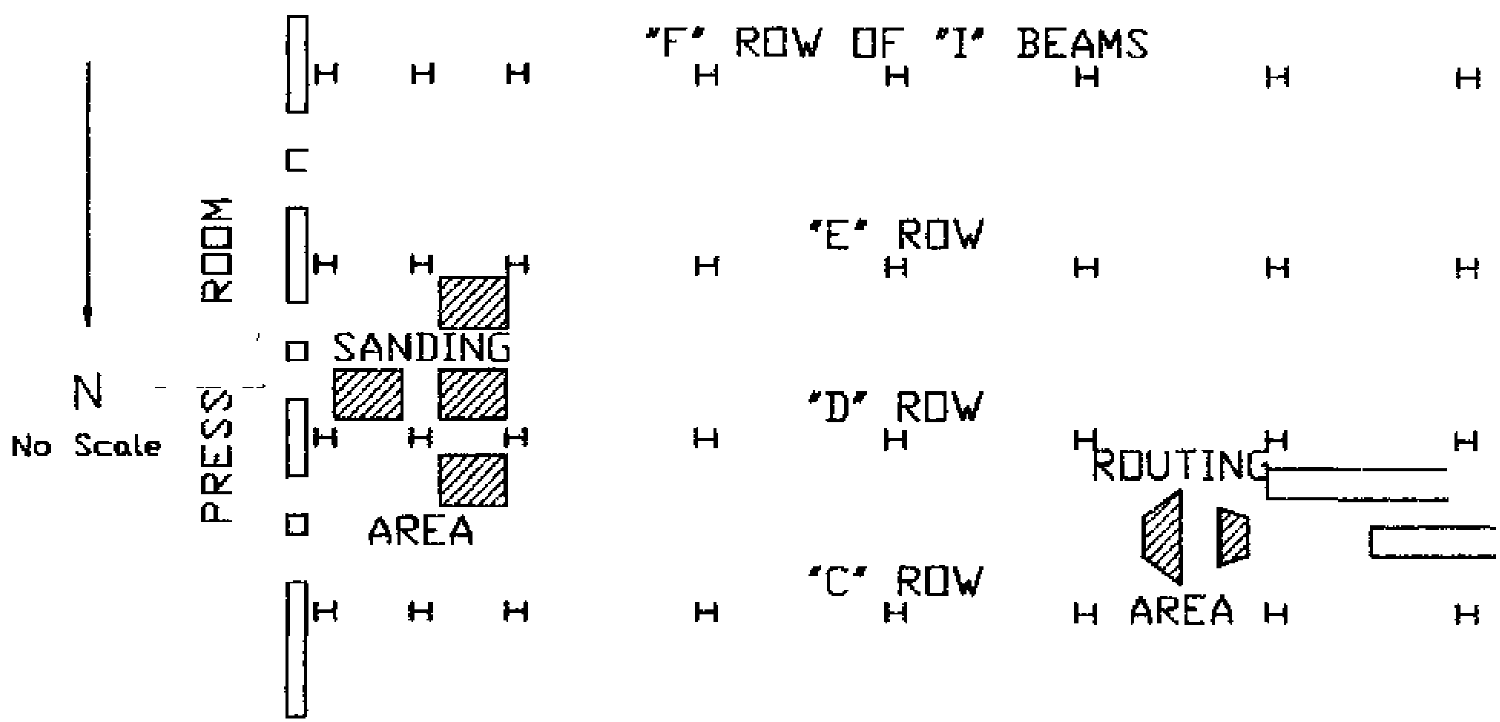


SANDING AND ROUTING AREAS AT NAVISTAR

COLUMBUS, OHIO

APRIL, 1987

Figure A-1

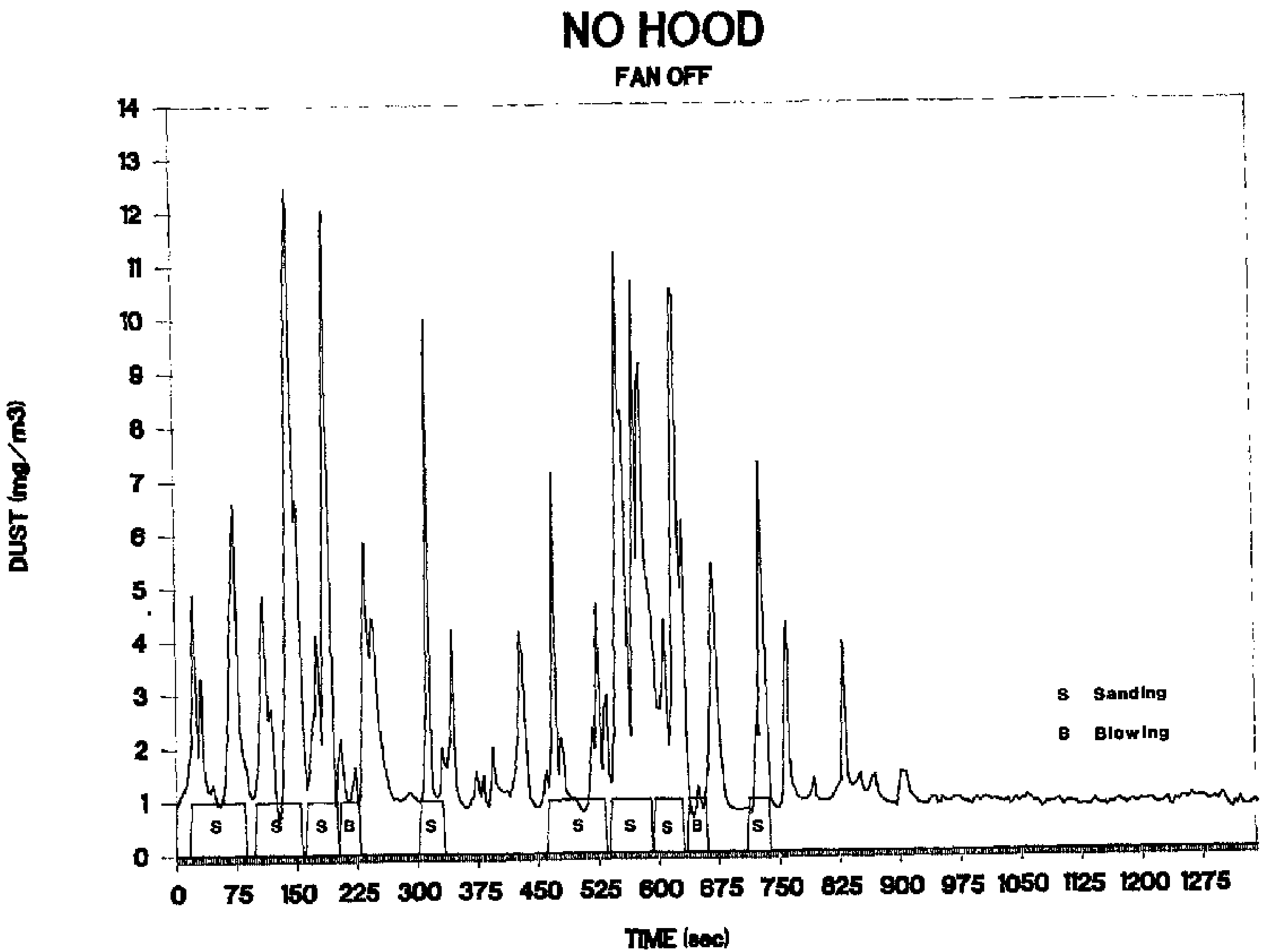


Figure A-2. Exposure activity profile: no hood, pedestal fan off.

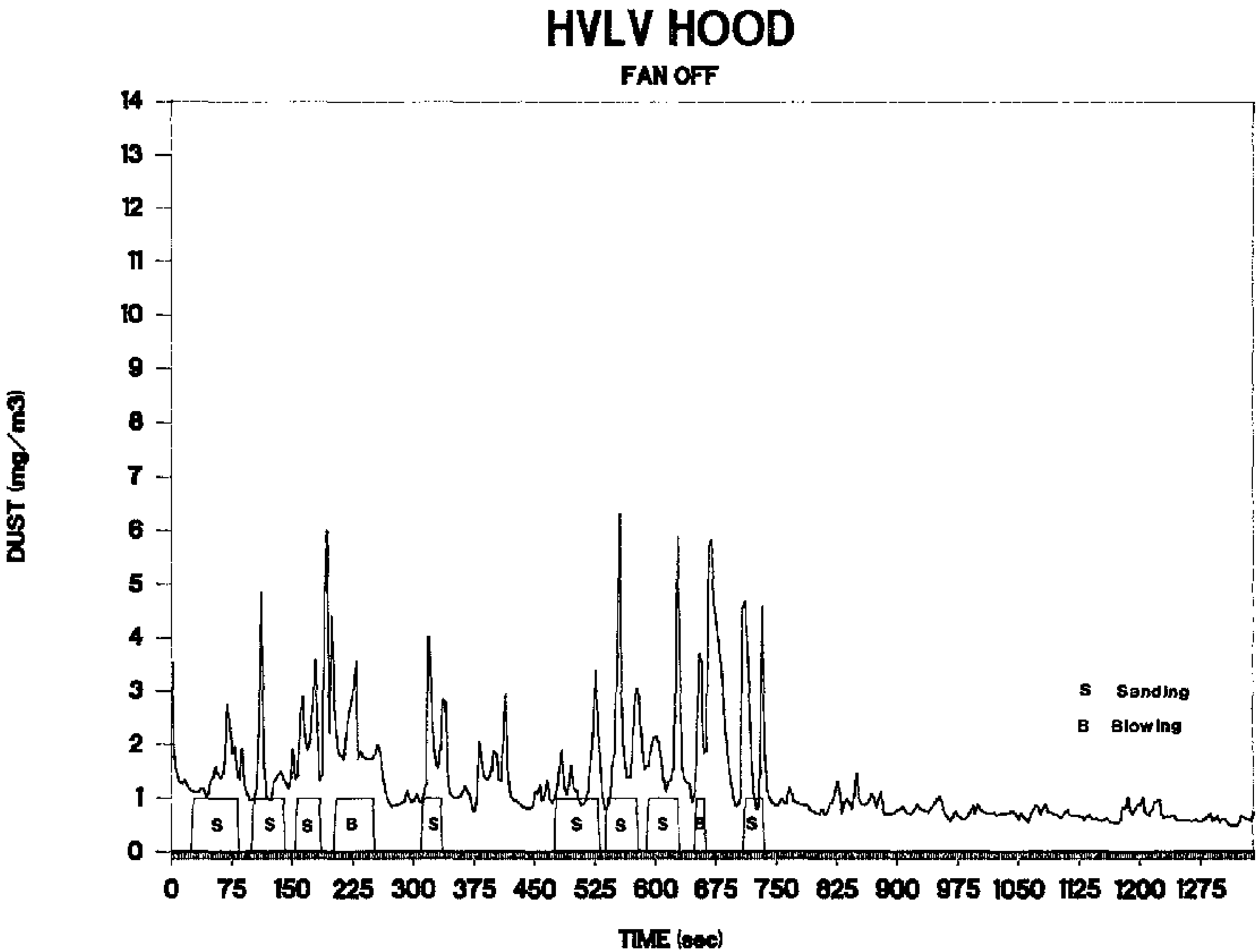


Figure A-3 Exposure activity profile. HVLV hood, pedestal fan off

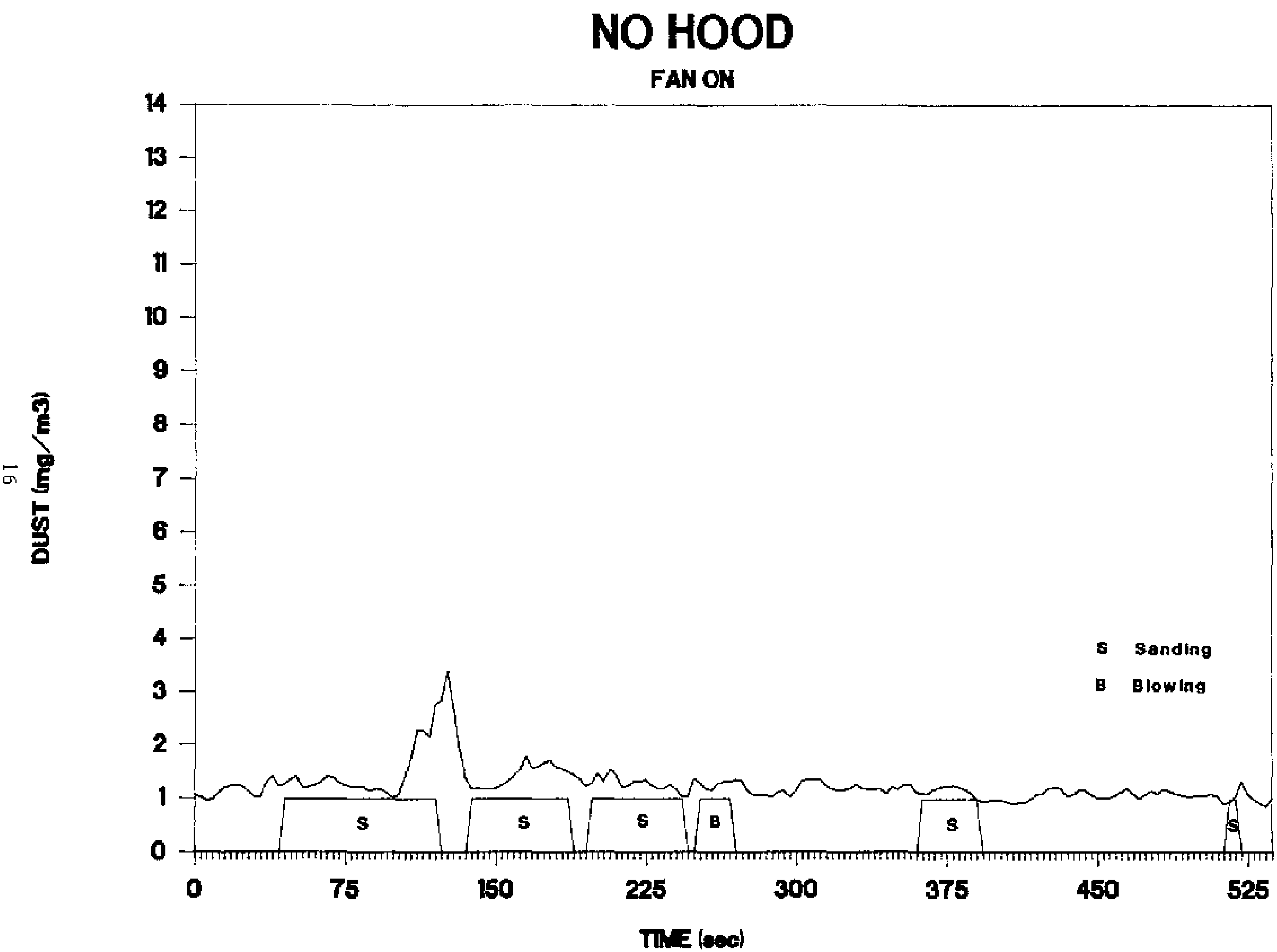


Figure A-4. Exposure activity profile: no hood, pedestal fan on.

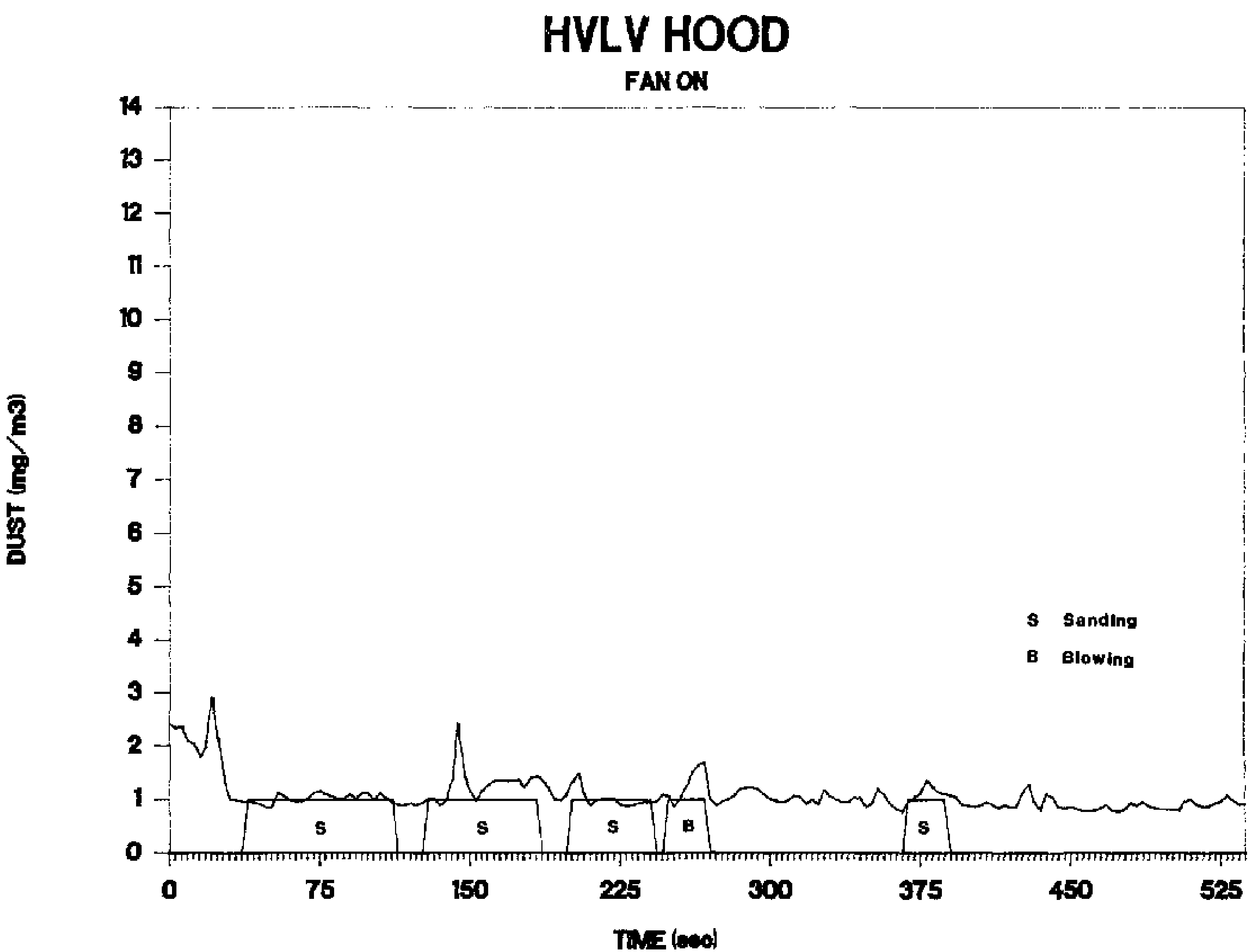
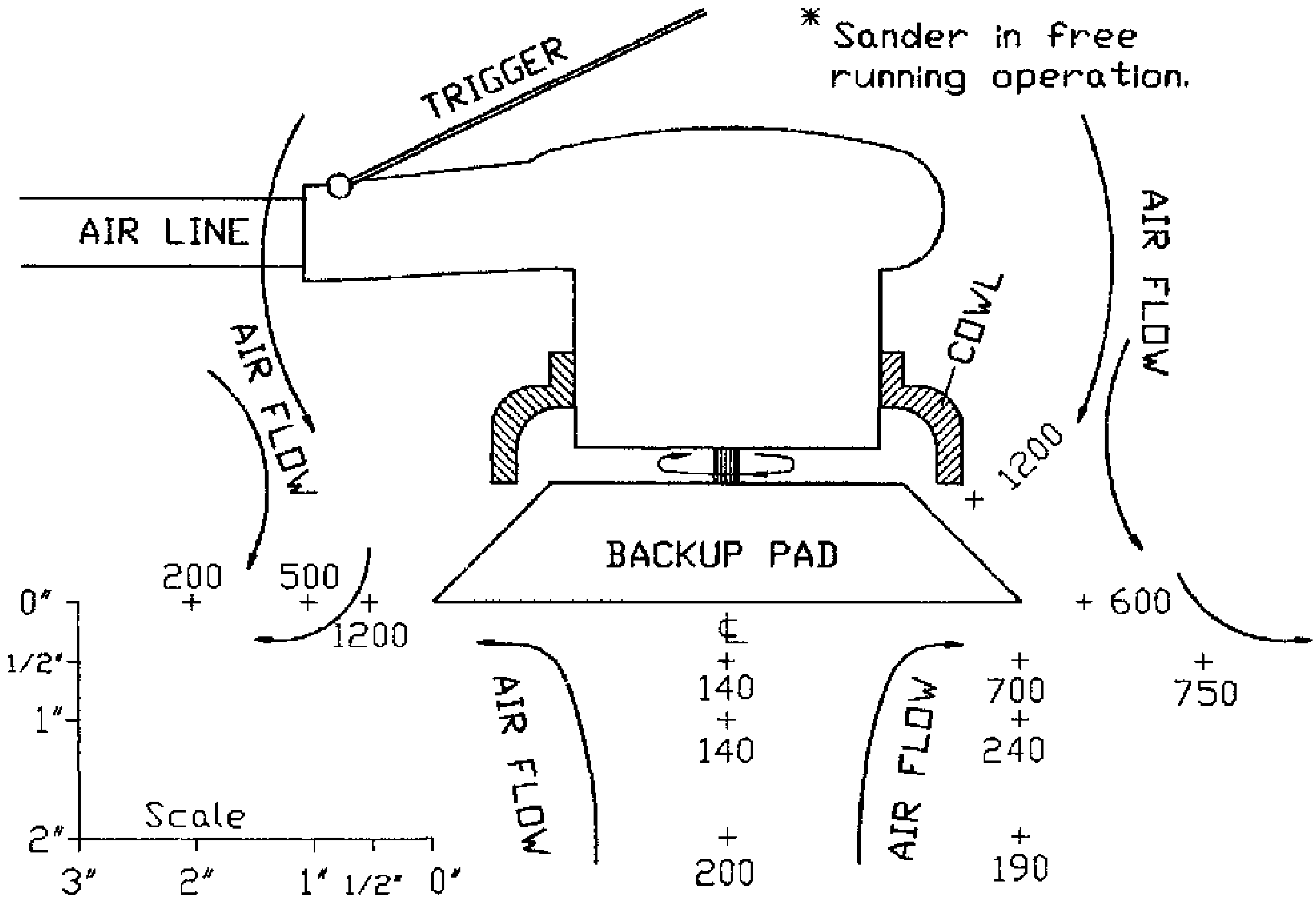


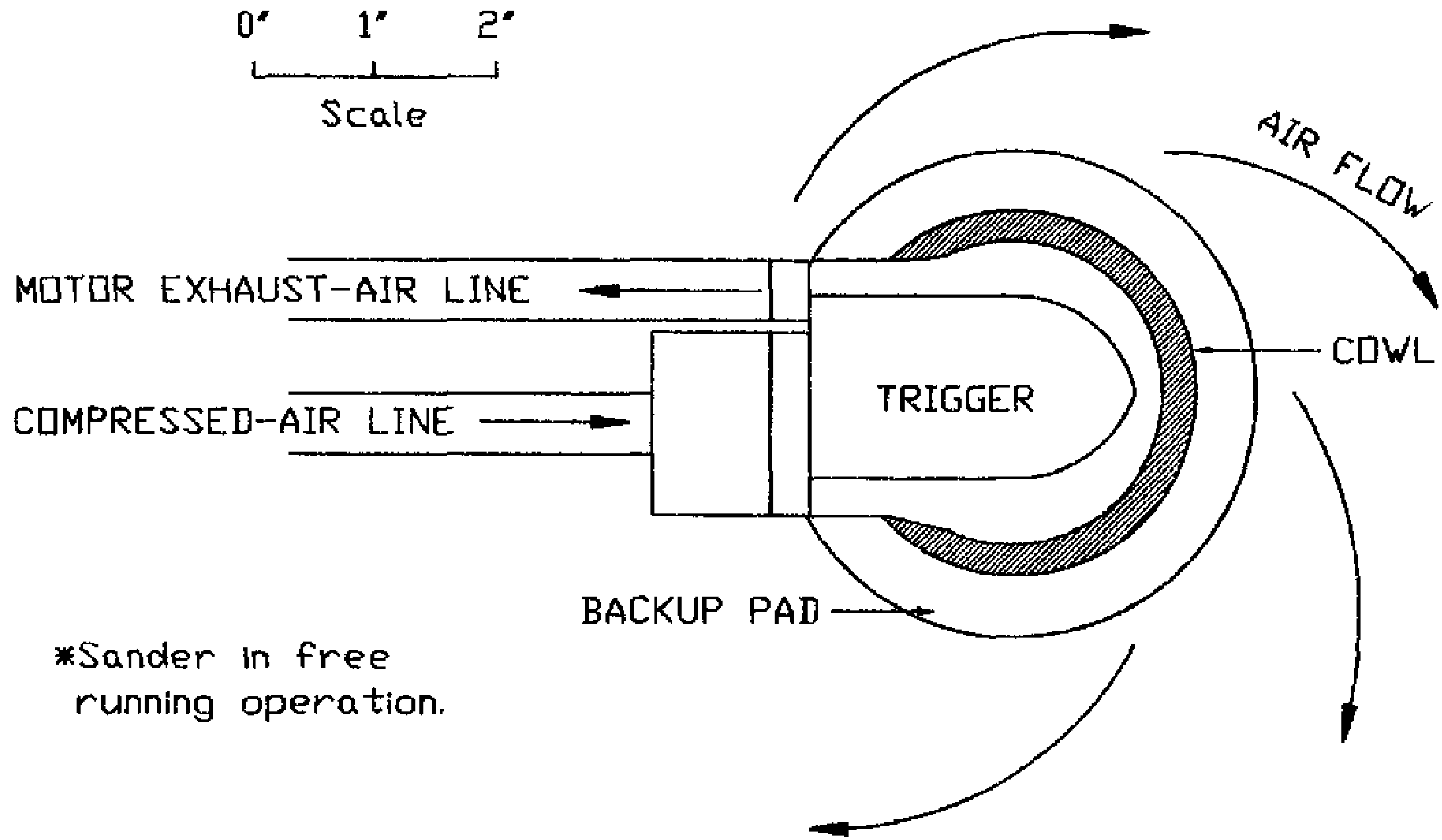
Figure A-5. Exposure activity profile: HVLV hood, pedestal fan on



PRE HVLV HOOD: Cross Section of Air Flow Patterns and Velocities (fpm) of Model 8446-A5 Sander

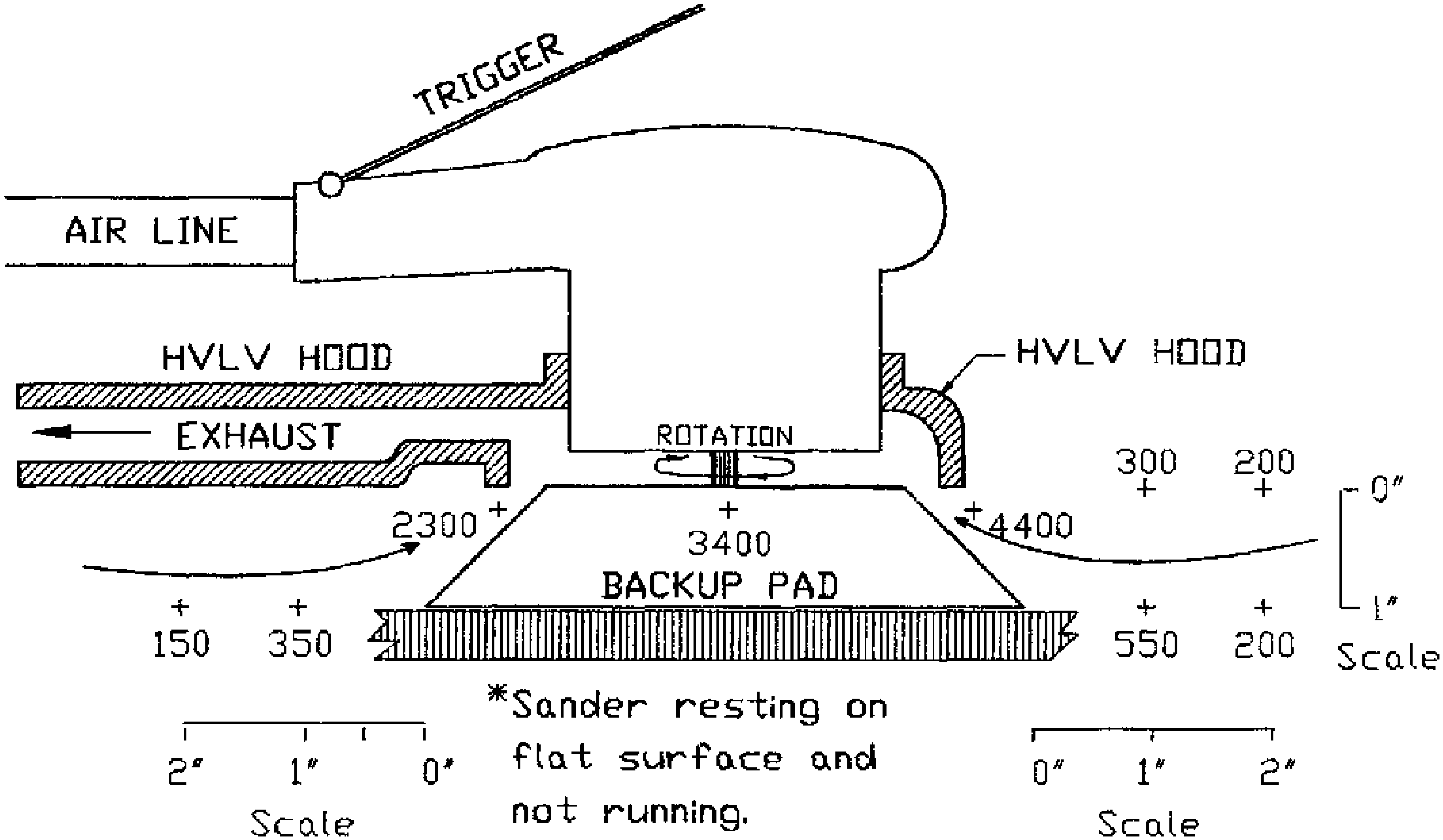
Figure A-6

A 6



PRE HVLV HOOD: Top View of Air Flow Patterns of Model 8446-A5 Sander

Figure A-7



POST HVLV HOOD: Cross Section of Air Flow Patterns and Velocities (fpm) of Model 8446-A5 Sander

Figure A-8