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In-Depth Survey Report

Control Technology for Agricultural Environmental Enclosures

at

Nelson Manufacturing Co , Inc

Bill Heitbrink comments 12/96

REPORT WRITTEN BY
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National Institute for Occupational Safety and Health
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PLANT SURVEYED	Nelson Manufacturing Co Inc Yuba City, CA 95993
SIC CODE	
SURVEY DATE	October 9-11, 1996
SURVEY CONDUCTED BY	Ronald Hall William Heitbrink James McGlothlin
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DISCLAIMER

INTRODUCTION

This study was conducted to provide information on the effectiveness of agricultural cabs and identify areas of improvement within the cab that are needed to enhance the enclosure's efficacy and protect the agricultural worker The enclosure evaluated is intended to protect workers from pesticides and other agriculture air contaminants Survey reports will be distributed to various agencies and persons according to standard procedures in 41 CFR 85a (Appendix A) and will be available from National Technical Information Service (NTIS)

STUDY OBJECTIVES

The main goal of the agricultural enclosures project is to evaluate the ability of enclosures on agricultural vehicles to reduce operator air contaminant exposure to pesticides and other agriculture air contaminants The three major objectives during this field evaluation were 1) to evaluate the effectiveness of the filter system, 2) identify aerosol size distribution inside and outside the enclosure, and 3) evaluate air infiltration into the cab by identifying potential leak sources

CAB DESIGN

Nelson Manufacturing Co , Inc designs and manufactures retrofit cabs for various tractor manufactures including John Deere, Ford, Massey Ferguson, and Kubota The tractor cabs manufactured by Nelson Manufacturing Co Inc meet the requirements of California EPA as an enclosed cab that can be used in place of respirator protection This field evaluation was performed on a Nelson Spray Cab® designed to fit on a Massy-Ferguson 396 tractor The cab is designed to pull fresh air into the ventilation system from the front top portion of the cab The fresh air flows through a filter system that consist of 3 separate filters The first filter is a pre-filter (paper filter to remove larger particles) that is followed by a High Efficiency Particulate Air Filter (HEPA designed with an efficiency of 99 97% with a maximum penetrating aerosol size of 0 3 µm) and an activated carbon filter After the air passes through the filters it is then blown into the cab through louvers located behind the operator seat and maintains positive pressure inside the cab

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need a description of overall approach as part of introduction

METHODS

need an overall description of approach and the evaluate cabs. might describe concept of protection fact

The following instrumentation was used to measure the concentration of ambient aerosol outside and inside of the cab

1 Hand-held Particle Counter (Model 227b, Met-One Inc, Grants Pass, OR) counts the number of individual particles larger than 0 3 µm The Hand-held Particle Counter (HPC) was used with a sampling rate of 2 8 liters per minute (lpm), a sampling period of 14 seconds, and a time between sampling periods of 1 second Two channels were used to store the number of particle counts in a time interval One channel stored the total number of particles counted greater than 0 3µm The second channel stored the total number of particles larger than 3 0 µm This instrument sizes the particles based upon the

amount of light scattered by individual particles [1]

2 Portable Dust Monitor (Model 1106, Grimm Labortechnik GmbH & CoKg, Ainring, Germany) counts the individual number of particles in eight size channels between 0 3 and 6 5 µm Particles are sized based upon the amount of light scattered by individual particles The Portable Dust Monitor (PDM) operates at a flow rate of 1 2 lpm [2]

3 PortaCount® Plus (Model 8020, TSI Incorporated, St Paul, MN) was used to measure ambient particle concentration inside and outside of the enclosure The ratio of the two measurements was used to calculate a protection factor Particles enter the PortaCount® Plus through a saturator tube where they are combined with alcohol vapor The particles then pass through a condenser where the alcohol condenses on the particles, which increases the particle size The enlarged particles then pass through a laser beam that produces flashes of light that are detected by a photodetector Particle concentrations are determined by the amount of light flashes The PortaCount® Plus has a particle range of 0 02 to greater than 1 µm with a flow rate of 0 1 lpm (TSI Incorporated, St Paul, MN) [3]

The PortaCount® Plus was used to measure leakage of particles (in the range of 0 02 - 1 0 µm) into the cab Condensation nuclei was measured in the ambient air outside the cab and inside the cab while the tractor was driven around a dirt lot The PortaCount® Plus is equipped with two sampling probes One sampling probe was used to collect aerosol concentrations inside the cab and the other sampling probe was used to collect ambient aerosol concentrations outside the cab This test was performed in an effort to evaluate the protection factor of the cab during field operations

The PortaCount® Plus collected twelve separate samples during the field test Each of the twelve separate samples were collected over a 60 second period A protection factor (ratio between particle concentrations outside and inside the enclosure) was calculated for each sample A low protection factor is an indicator of particle leakage into the cab or an indicator of particle generation sources inside the cab

During this evaluation, one HPC and PDM were placed inside the tractor cab to count particles These instruments were used to evaluate the enclosure's overall ability to protect the worker from aerosol exposure Another HPC and PDM were placed directly outside the cab near the air intake During this evaluation, we switched the instruments to obtain additional readings The instruments located inside the cab were placed outside, and the instruments located outside the cab were placed inside The HPCs and PDMs were ran for approximately 30 minutes and then switched This process was repeated 4 times This process was conducted in an effort to collect enough data for analyzation and limit the amount of instrument bias

All measurements taken inside and outside of the enclosure were collected while the tractor was driven around a dirt lot The tractor was driven around the dirt lot in an effort to assess the integrity of the cab, how well it remains sealed, and it's ability to remove particulate in field conditions

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Data analysis and evaluation

All data collected from the HPC and PDM were downloaded into a portable computer and placed in a spreadsheet for analysis Penetration of different size aerosols, efficiency of the filter system, and protection factors were determined by comparing data collected (with the HPC and PDM) inside the enclosure with data collected directly outside the enclosure

Ventilation Measurements

The air velocity into the fresh air inlet and out the exhaust of the louvers (inside the cab) were measured with a velometer An autozero digital micromanometer, MP series 4 (Solomat, a Neotronics company, Norwalk, CT), was used during the field test to measure pressure inside the cab A metrosonic dl-3200 data logger (Metrosonic Inc , Rochester, NY) was used to record the data output of the digital micromanometer throughout the field evaluation

RESULTS

Results of the HPC are summarized in Figure 1 The HPC counts naturally occurring ambient particles in the size range of 0 3 - 3 0 µm and particles grater than 3 0 µm The HPC results during this survey indicate that the filter system in the cab was 86% efficient at removing particles in the size range between 0 3 and 3 0 µm with a protection factor (outside concentration/inside concentration) of 7 in this range The HPC results also indicated that the ventilation system in the cab was 99 6% efficient at removing particles larger than 3 0 µm with a protection factor of 250 (outside/inside concentration ratio)

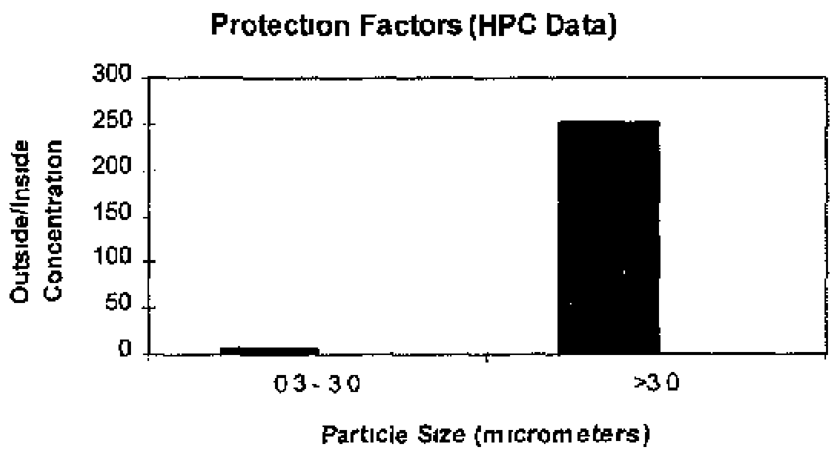


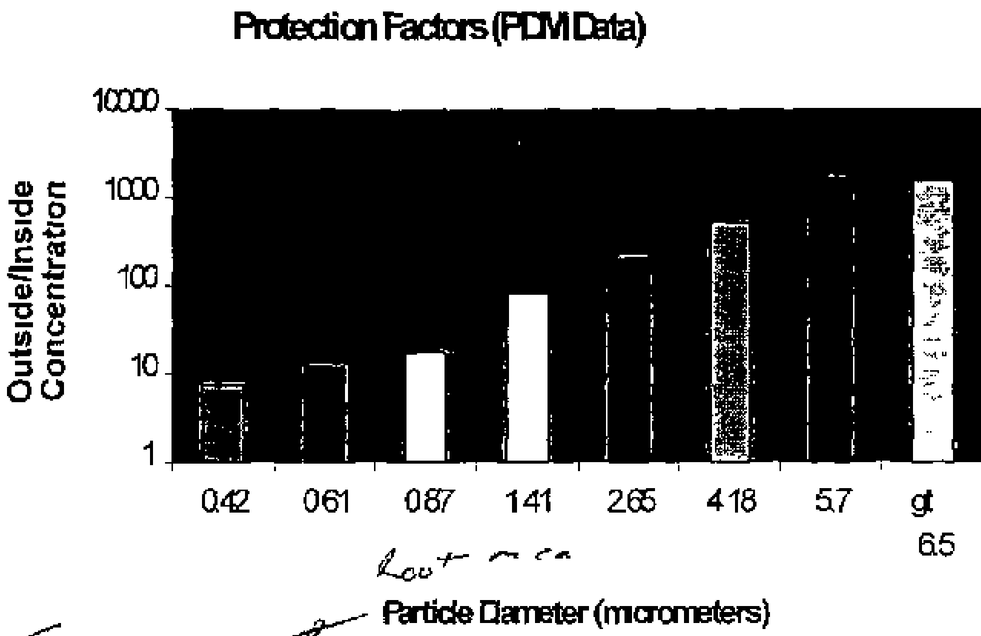
Figure 1 HPC Data Protection Factors (outside concentration/inside concentration)

PDM results indicated that the ventilation system on the cab was 99% efficient at removing particles larger than 2 6 µm The filtration efficiency of the cab at each different size range measured by the PDM are listed in Table 1

Table 1 Filtration Efficiency by particle size

Particle Size (µm)	0 42	0 61	0 87	1 41	2 65	4 18	5 7	6 5
Efficiency of Cab	85 3%	91 0%	93 1%	98 1%	99 1%	99 7%	99 7%	99 7%

The PDM results were also used to calculate protection factors at each separate particle size These protection factors are shown in Figure 2 The protection factor increased as the particle size increased Protection factors were larger than 100 for particles greater than 2 65 µm



The PortaCount® Plus results confirmed the data collected with the HPC and PDM The PortaCount® Plus counts particles smaller than 1 µm As indicated by the HPC and PDM the filtration system on the cab was less efficient for removing smaller particles Three separate test runs were conducted with the PortaCount® Plus Each of these test runs consisted of 12 individual protection test The average protection factor for all the test was 16 (outside concentration/inside concentration)

Ventilation measurements were collected at the air louvers inside the cab These air louvers are located in the back of the cab behind the operator The area of the opening in the air louvers is 0 2 square feet The average air velocity exiting these openings was 1300 fpm which resulted in an air volume of 260 cfm Pressure measurements inside the cab were collected with an autozero digital micromanometer The data output of the micromanometer was recorded with a data logger The pressure remained positive inside the cab during our evaluation with an average pressure reading of 0 3 inches of water

CONCLUSIONS

The HPC and the PDM both indicated that the cab is more than 99% efficient at removing aerosols larger than 3 0 µm in diameter and provides protection factors (outside/inside concentration ratio) greater than 250 for particles larger than 3 0 µm The results obtained with the PortaCount® Plus indicate that the cab provided an average protection factor of 16 (outside/inside concentration ratio) for aerosols smaller than 1 0 µm in diameter As the particle size decreases (< 2 µm), the efficiency of the cab starts to decrease (see Table 1), which indicates that there may be some leakage of small particles into the cab

The pressure measurements collected inside the cab indicated that the cab remained under positive pressure during our evaluation at an average of 0 3 inches of water The positive pressure inside the cab reduces the possibility of aerosols entering the cab through leak sources other than around the filters in the ventilation system Therefore, any leakage of small particles (less than 2 µm) into the cab may be a result of these small particles penetrating around the seals used to hold the filters in place in the ventilation system However, it is also a possibility that some of the small aerosols (inside the cab) could be generated by the blowers or generated from the operator movement inside the cab

REFERENCES

1 Met One, Inc Model 227 Hand-Held Particle Counter, Operating Guide, Met One, Inc Grants Pass, Oregon

2 Grimm Dust Monitor Instruction Manual, Series 1 100 v 5 10 E, Grimm Labortechnik GmbH & Co KG, Ainring, Germany

3 TSI [1993] PortaCount®Plus Model 8020, Operation and Service Manual, Rev C, TSI Incorporated, St Paul, MN

Need An Appendix listing the Raw Counts?