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AIR CURTAIN MACHINES FOR FOOD SERVICE FACILITIES.(U)

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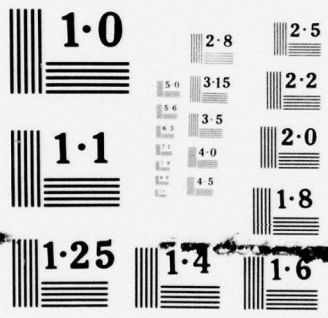
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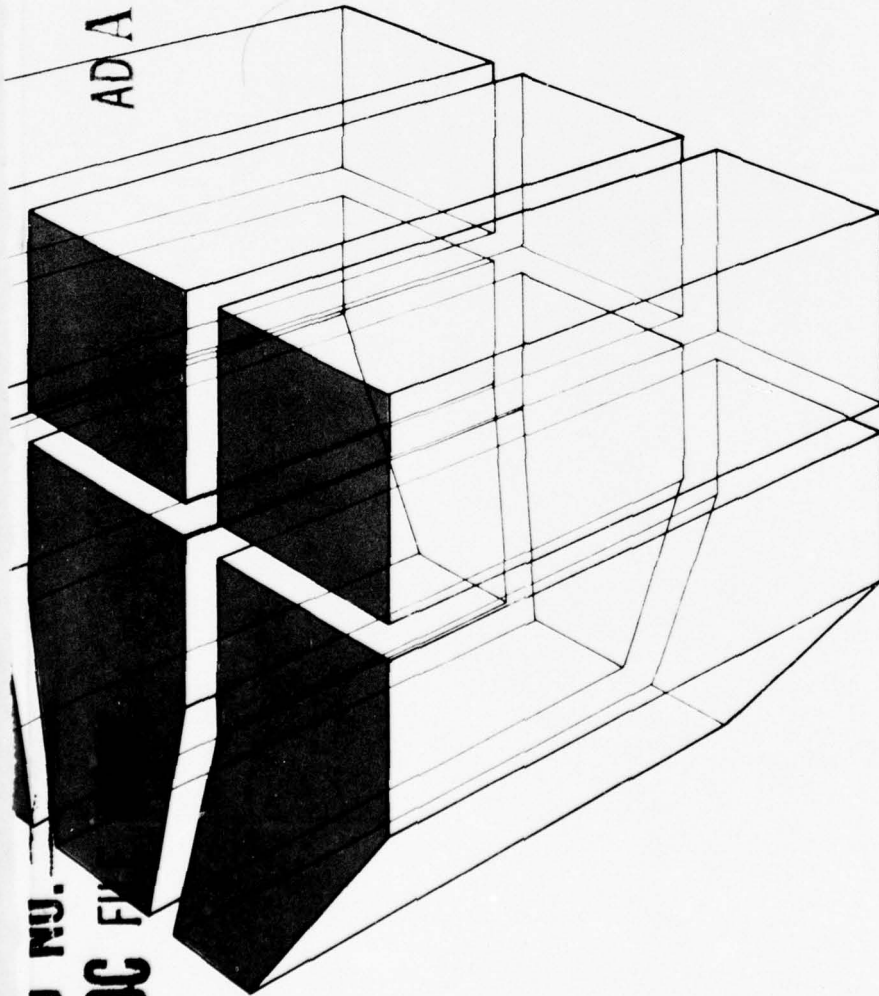
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TECHNICAL REPORT E-104  
April 1977

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AIR CURTAIN MACHINES FOR FOOD SERVICE FACILITIES



by  
Dominic Eng

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number) The objectives of this study were to ascertain the effectiveness of air curtain machines in excluding small insects from food service and commissary facilities, and to provide design guidance and installation information for such machines.  A limited field survey of Army and Air Force installations indicated that most of the air curtain machines have been ineffective in excluding small flying insects, due to product deficiency and insufficient technical maintenance guidance. These problems		

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have sometimes been compounded by improper equipment installation and maintenance.

Manufacturers' catalog information, which was carefully studied and analyzed, is summarized, as is an isothermal jet computer analysis used to model the centerline velocity of the air curtain for varying air thicknesses and throws.

Recommended corrections to air curtain machine deficiencies and engineering criteria, and changes to existing publications that will result in reasonably effective air curtain performances are presented. These can provide more effective insect exclusion.

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## FOREWORD

This study was conducted for the Directorate of Military Construction, Office of the Chief of Engineers (OCE), under AOA 08-9644. The OCE Technical Monitor was Mr. William B. Holmes, DAEN-MCE-A.

This work was performed by the U.S. Army Construction Engineering Research Laboratory (CERL), Energy and Power Division (EP), Electrical-Mechanical Branch (EPM), Champaign, IL. The CERL Principal Investigator was Mr. D. Eng.

Appreciation is extended to COL T. L. Everhart (U.S. Army Troop Support Agency), MAJ J. O. May (U.S. Air Force Surgeon General/Veterinarian), Mssrs. S. Hiratsuka (DAEN-MCE-U), F. DiMarco (U.S. Air Force Food Service System's Office), M. J. Pollock (Chief, CERL-EPM), and B. Sharrava, J. Hall, and G. Tietz (CERL) for their help and guidance in conducting this study. The help of manufacturers' representatives in providing technical information is greatly appreciated.

COL J. E. Hays is Commander and Director of CERL and Dr. L. R. Shaffer is Technical Director. Mr. R. G. Donaghy is Chief of EP.

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## CONTENTS

	Page
DD FORM 1473 .....	1
FOREWORD .....	3
1 INTRODUCTION .....	5
Background	
Objectives	
Approach	
Organization of Report	
2 AIR CURTAIN MACHINES .....	6
Description	
Operational Terminology	
Operation	
Results of Literature Review	
Theoretical Modeling of an Air Curtain	
3 FIELD SURVEY .....	9
4 CONCLUSIONS AND RECOMMENDATIONS .....	13
Conclusions	
Recommendations	
REFERENCES .....	13
APPENDIX A: Summary of Manufacturers' Data .....	15
APPENDIX B: Recommended Design Guidance and Changes to Existing Specifications .....	19
APPENDIX C: Federal Specification 00-B-1620 .....	21
DISTRIBUTION	

## AIR CURTAIN MACHINES FOR FOOD SERVICE FACILITIES

### 1 INTRODUCTION

#### Background

Using wire or fabric screening on doors to exclude small flying insects is not always possible, particularly where traffic through the door is heavy, the insect population in the immediate area surrounding the doorway is dense, and little if any insect entry can be tolerated. The use of air curtains to exclude small flying insects, mainly flies, from food service and commissary facilities has been a common practice on military installations.<sup>1</sup> In addition to their insect exclusion application, air curtains have been used over doorways subject to heavy traffic to prevent excessive loss of conditioned air from buildings.<sup>2</sup>

Although previous Air Force research had indicated that properly designed and installed air curtains are about 80 percent effective (which is more effective than screen doors),<sup>3</sup> an extensive air curtain survey at various installations indicated that air curtains provided "substandard performance" for exclusion of flying insects from food service and commissary facilities.<sup>4</sup> The Air Force also reported that while the use of air curtains for insect exclusion is widespread in planned and existing military facilities, little design guidance on equipment installation and maintenance is available to Army Corps of Engineers District Offices, facilities engineers, and Air Force Civil Engineers. A literature search revealed that Air Force Manual (AFM) 163-8<sup>5</sup> has some guidance on air curtains, but is of little help because of its lack of specifications.

<sup>1</sup>An *Engineering Evaluation of Air Curtains at Doorways for Exclusion of Insects From Food Service Facilities*. Report IMSW-BEE-74-147 (Department of the Air Force, August 1974); and *Engineering Instructions, Commissary Store Construction Program*, FY 76 MCA and Surcharge Programs (Office of the Chief of Engineers, 20 May 1974).

<sup>2</sup>E. J. Kurk, "All About Air Entrance," *Air Engineering*, Vol 4, No. 6 (June 1962), pp 38-42, and Vol 4, No. 7 (July 1962), pp 39-40, 45.

<sup>3</sup>An *Engineering Evaluation of Air Curtains at Doorways*.

<sup>4</sup>Letter, HQ, Air Force Logistics Command, DPS, Subject: Air Curtain Survey (11 October 1974), with inclosure, HQ, Air Force Logistics Command, SGV, Subject: Air Curtain Survey (2 October 1974); and Letter, HQ, SAC, Subject: Unsatisfactory Performance of AFSO Recommended Air Curtain (20 August 1975).

<sup>5</sup>*Food Service Sanitation*, AFM 163-8 (Department of the Air Force, 23 February 1972).

Although Office of the Chief of Engineers (OCE) and Navy Facilities Engineering Command (NAV-FAC) personnel have indicated that neither the Army or Navy has its own design guidance on air curtains, Federal Specification 00-B-1620<sup>6</sup> has been approved for use by all Federal agencies. The existence of this specification may be the reason the Army and Navy have not developed their own design guidance. Although the specification provides more guidance than AFM 163-8, it does not provide adequate guidance for properly specifying an air curtain machine. As a result, in July 1975, OCE asked the U.S. Army Construction Engineering Research Laboratory (CERL) to evaluate and ascertain the capacities and limitations of air curtains for insect exclusion, and to develop design guidance for the proper design, specification, and installation of air curtains to be used by Corps of Engineers District Offices and facilities engineers.

#### Objectives

The objectives of this study were to:

1. Investigate the adequacy and effectiveness of commercially available air curtain machines in preventing insects from entering food service and commissary facilities.
2. Provide design guidance and installation information for air curtain machines in planned and existing facilities. The guidance was to be designed for use by architect-engineers under contract to Corps of Engineers District Offices and facilities engineers.

#### Approach

The following steps were used to accomplish the goals of this study:

1. A literature search was conducted, and pertinent reference material, including catalogs and data provided by air curtain manufacturers, was reviewed.
2. A computerized simulation of the air stream centerline velocity profile was conducted.
3. Preselected Army and Air Force installations were surveyed to observe and evaluate on-site problems of air curtain machines.

<sup>6</sup>*Blower, Air Barrier*. Federal Specification 00-B-1620 (General Services Administration, 26 September 1973).

4. Based on the information gained in the first three steps, design criteria were developed.

### Organization of Report

Chapter 2 describes the air curtain machine and summarizes the results of the literature survey and computer simulation. Chapter 3 summarizes the field survey of Army and Air Force installations, including problems found in the field that contribute to ineffective performance and deficient design of available air curtain machines. Chapter 4 presents the conclusions and recommendations. Appendix A summarizes the manufacturers' catalog data, and Appendix B presents the design guidance and recommended changes to applicable existing specifications.

## 2 AIR CURTAIN MACHINES

### Description

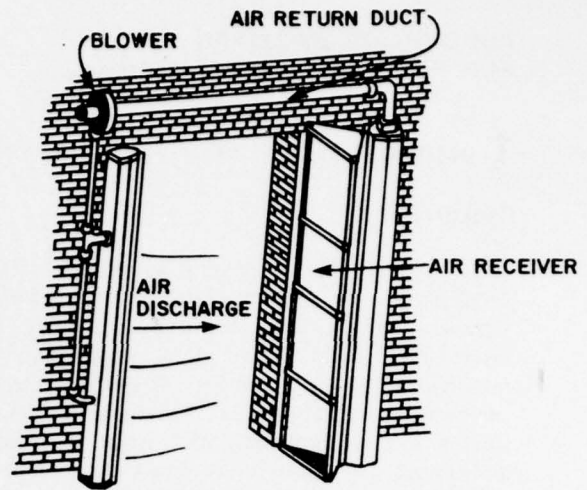
An air curtain machine has two purposes:

1. To repel flying insects by providing a sufficient outward air vector from a doorway.
2. To discourage flies from gathering around the area surrounding a doorway by taking advantage of the fact that insects avoid a suddenly changing environment.

Names such as air curtain fan, air barrier, air screen, fly fan, fly chaser fan, and fly screen have been used interchangeably throughout the air curtain industry. Although no formal definition of an air curtain exists, the scope of Federal Specification 00-B-1620 describes it as ". . . a nonpositive displacement mechanical device having an axial or centrifugal fan impeller inclosed within a housing with an exhaust nozzle and baffles. It is designed to move air across an open entrance to provide an air barrier to . . . repel flying insects."<sup>7</sup>

There are two general classes of air curtains: recirculative and nonrecirculative. In a recirculative air curtain, the air discharge outlet is located directly opposite the receiver (Figure 1). The receiver recovers the discharged air and recirculates it through interconnecting ducts back to the discharge outlet.

<sup>7</sup>Blower, Air Barrier, Federal Specification 00-B-1620 (General Services Administration, 26 September 1973).



### SIDE MOUNTED UNIT

Figure 1. Recirculative air curtain.

The nonrecirculative type, which has no return duct, simply discharges the air into the space where insect exclusion is intended (Figure 2). Nonrecirculative air curtains can be either the down-draft type, which is most commonly used in department and grocery stores, or the cross-feed type.

### Operational Terminology

The following terms are used to describe the operation of an air curtain machine:

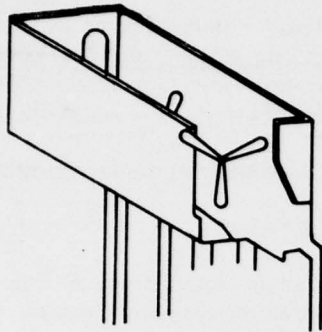
**Air stream:** A mechanically induced layer of air that is employed at a doorway to prevent flying insects from entering a facility.

**Angle of throw:** The angle (in degrees) between the maximum centerline velocity and the vertical; to be measured on the horizontal plane, 3 ft (0.9 m) above the floor.

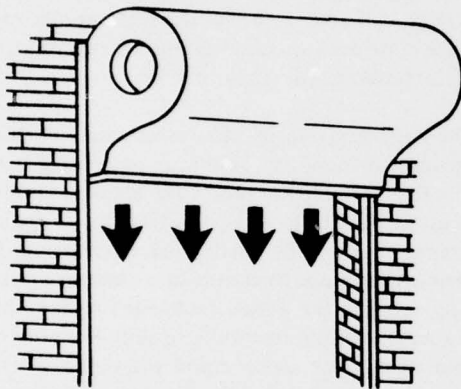
**Aspect ratio:** The ratio of the length of the discharge outlet to its width.

**Directional controller:** Vanes or dampers used to control the angle of throw.

**Discharge outlet:** The opening from which the air stream is projected. The thickness of the air stream measured at the outlet in a vertical plane perpendicular to the door opening is the minimum thickness of the air stream.



a. Overhead propeller unit.



b. Overhead squirrel cage unit.

**Figure 2.** Nonrecirculative air curtain.

**Initial velocity:** The air stream velocity of the discharge outlet. It is equivalent to the volume of flow at the designed motor speed, divided by the free discharge area.

**Mechanical efficiency:** Ratio of power output to power input.

**Negative pressure:** Differential between the indoor and outdoor pressure due to insufficient ventilation system make-up air.

**Power input:** Measured horsepower delivered to the fan shaft at a rated motor speed.

**Power output:** Power output of a fan volume and fan total pressure.

**Static pressure:** Total pressure minus the fan velocity pressure.

**Thickness of the air stream:** Front to back thickness of the air stream measured at the discharge outlet on a vertical plane perpendicular to the doorway.

**Velocity:** The speed of the air molecules to be measured in feet per minute.

**Velocity pressure:** The pressure corresponding to the average velocity determined from the volume of air flow at the fan outlet areas.

**Volume of flow:** The number of cubic feet of air per minute expressed at fan outlet conditions.

### Operation

The energy content of a stream of air issuing from a duct into the atmosphere is primarily a function of the exit velocity. The change in momentum from entrance to exit for isothermal air is exactly offset by the change in total pressure. The velocity pressure at the exit represents a corresponding amount of kinetic energy. Thus, when the air stream must be projected a great distance from the exit, a high exit velocity is mandatory. The fan must supply the corresponding energy content through the electric motor. In addition, the fan must supply energy to overcome the internal friction loss of the air curtain unit.

### Results of Literature Review

In a facility and equipment fact sheet published in 1963,<sup>8</sup> the U.S. Department of Agriculture (USDA) endorsed the use of air curtains in food-handling establishments. The fact sheet stipulated four basic requirements for an air curtain machine:

1. Velocity of the air stream must be at least 1600 ft/min [488 m/min] (about 18 mph [29 km/hr]) at a point 3 ft (0.9 m) above the floor for overhead mounted units, or 1600 ft/min (488 m/min) across the entire opening for side-mounted units. In either case, the air stream should be at least 2 in. (50.8 mm) wide (preferably 5 in. [127.0 mm]) to assure a satisfactory barrier against persistent flying or crawling insects.

2. In both overhead or side-mounted units, the air stream must cover the entire opening. Unenclosed and ductless overhead fans are seldom effective because the air stream produced is likely to dissipate before reaching floor level, thus providing uneven protection.

<sup>8</sup>Fact Sheet MID-FE-1 (U.S. Department of Agriculture, 8 March 1963).

3. The air stream from overhead units should be directed downward and slightly outward, while streams from side-mounted units should be directed so they converge at a midpoint just outside the opening to be protected.

4. The air-stream-producing device should be designed to produce full air movement instantly when the motor is switched on. The switch should be installed so that the motor is activated automatically and immediately when the door is opened.

USDA no longer endorses this publication, however, because several other factors, such as local wind conditions, angle of throw, and negative pressure inside the facility, affect air curtain performance.

AFM 163-8 directs that air curtain fans be used over doorways where screen doors cannot be installed or where frequent use negates their effectiveness. AFM 163-8 covers only two factors—velocity and width. It requires that the air stream be the width of the door opening and that the air velocity be maintained at 1600 ft/min (488 m/min), 3 ft (0.9 m) above the floor. It does not consider the local wind design conditions.

The minimum velocity of 1600 ft/min (488 m/min) at 3 ft (0.9 m) above floor level is apparently based on a curtain thickness of at least 5 in. (127.0 mm). The requirement that the air stream should cover the full width of the doorway appears obvious; however, the manual does not specify that the discharge outlet should be the same length as the width of the door. Thus, some manufacturers might suggest that their standard unit discharge outlet would provide complete coverage even though it is smaller than the width of the door, because the air stream will fan out after it leaves the outlet. However, for insect control, the air stream should be directed toward the outside. The consensus of the literature<sup>9</sup> is that the angle should be 15 degrees from the vertical and directed toward the outside.

Federal Specification 00-B-1620, which is presented in Appendix C, was found to be the most extensively written specification on air curtain machines. It covers the four necessary parameters: velocity, thickness, width, and angle of throw of the

air stream. However, improvements are necessary to assure proper air curtain machine performance under various environmental conditions. Suggested improvements are presented in Appendix B.

### Theoretical Modeling of an Air Curtain

#### *Isothermal Jet Flows*<sup>10</sup>

In general, an air curtain draws air from a space, accelerates the air molecules, and discharges the air back into the space at a higher velocity, but still in the subsonic region. Hence, one can assume (to a high degree of accuracy) that the temperature in the space is quite uniform and that the air curtain can be approximated by an isothermal jet.

The centerline velocity of an isothermal jet emerging from a rectangular discharge outlet will persist for the first four thicknesses of the air stream (measured at the outlet), in which the integrity of the core will remain practically unchanged. From about four times the air stream thickness to a distance approximately equal to the width, multiplied by four times the aspect ratio, the centerline velocity (for rectangular outlets of large aspect ratio) will decrease as the square root of the ratio of the air stream thickness to the throw.

From the Streamline equation for an isothermal flow, the centerline velocity ( $V_x$ ), at a distance  $X$  (feet) from the outlet is

$$V_x = V_o \sqrt{\frac{KH_o}{X}} \quad \text{for } \frac{X}{H_o} \geq 4.94 \quad [\text{Eq 1}]$$

where  $V_o$  = the initial outlet discharge centerline velocity (fpm)

$H_o$  = the thickness (feet) of the air stream at the discharge

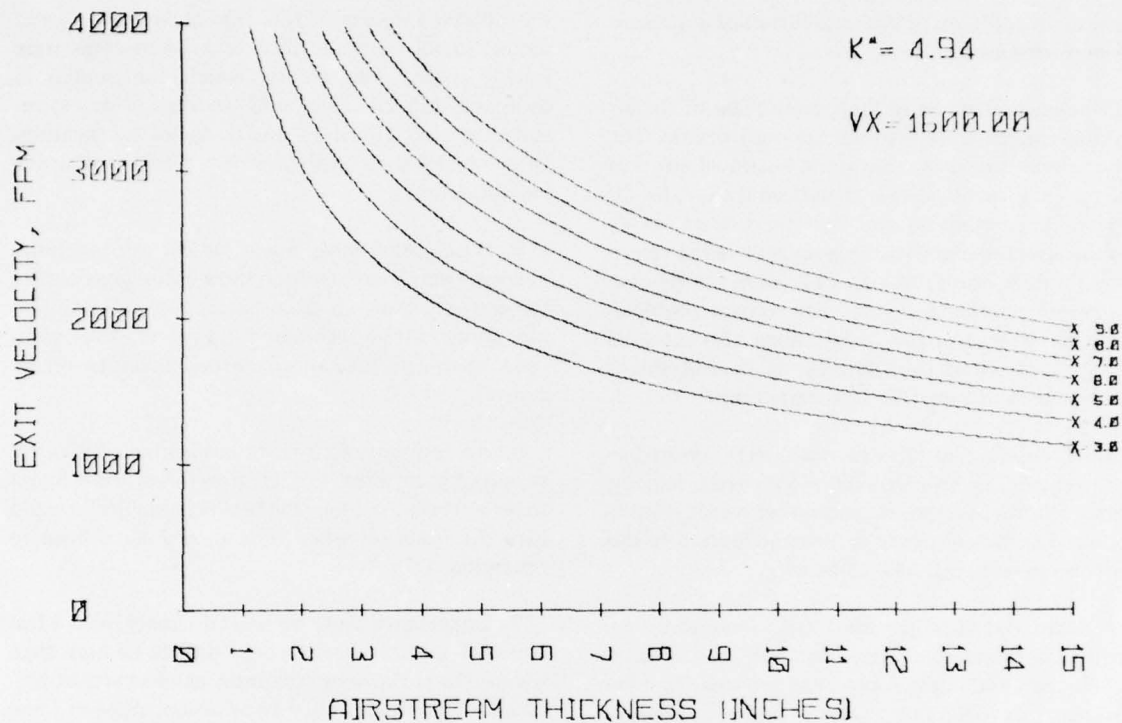
$X$  = the throw (feet) of the air stream from the discharge

$K$  = the numerical constant used.

The numerical constant in the equation reflects a discharge grille with a small deflection angle. A computer program was written to evaluate what initial velocity and air stream thickness are required to produce a required terminal velocity. Figure 3 shows the

<sup>9</sup>An Engineering Evaluation of Air Curtains at Doorways for Exclusion of Insects From Food Service Facilities, Report No. IMSW-BEE-74-147 (Department of the Air Force, August 1974).

<sup>10</sup>ASHRAE Handbook of Fundamentals (American Society of Heating, Refrigerating, and Air Conditioning Engineers, 1972); and Fan Engineering, seventh edition (Buffalo Forge Company, 1970).



**Figure 3.** Computer simulation results for centerline velocity of 1600 ft/min (488 m/min). SI conversion factor: 1 in. = 25.4 mm; 1 ft/min = 0.3048 m/min.

results for a terminal velocity of 1600 ft/min (488 m/min). These results were used in formulating the recommended design guidance presented in Appendix B.

The initial outlet discharge centerline velocity ( $V_0$ ) can be calculated from

$$V_0 = Q/A_0 \quad [\text{Eq 2}]$$

where  $Q$  = the volume of flow (cfm)  
 $A_0$  = the air curtain unit outlet free area (sq ft).

#### Air Stream Profile<sup>11</sup>

The angle of expansion is well defined near the outlet, but the boundary contours are somewhat billowy and are easily affected by external influ-

<sup>11</sup>G. E. McElroy, *Air Flow at Discharge of Fan—Pipe Lines in Mines*, Report of Investigation, R. I. 3730 (U.S. Bureau of Mines, November 1943), p 19; and *Carrier Company: Handbook of Air Conditioning System Design* (McGraw-Hill Book Company, 1965).

ences. The rectangular outlet will produce a jet that rapidly expands into an elliptical cross-sectional shape at a short distance from the outlet face, and then to a circular shape. The rate of expansion depends primarily on the aspect ratio and air stream thickness. Measured angles of expansion for discharge into large open spaces have usually ranged from 19 to 24 degrees with an average of 22 degrees. Jets discharging into relatively small spaces, such as vestibules, show smaller angles of expansion.

### 3 FIELD SURVEY

Army and Air Force installations were visited to observe and evaluate the deficiency in air curtain machine performance. Army installations visited were Fort Hood, TX, Fort Lee, VA, and Fort Benning, GA. Air Force installations visited included Chanute AFB, IL, Offutt AFB, NE, McClellan AFB, CA, and Kelly AFB, TX. The evaluations were based on installation and performance effectiveness, unit operating conditions, and environmental conditions affecting equipment effec-

tiveness. In addition, opinions of installation personnel were obtained.

Personal opinion as to the effectiveness of the air curtains ranged from favorable to unfavorable. The only general conclusion that could be drawn was that most management personnel indicated that the air curtains were effective and that there were no fly problems on the premises. Personnel from the veterinarian offices who were asked to assess the fly-control problem indicated that flies were a problem. Personnel at two of the installations also reported favorable reactions to electronic fly control (black light) devices in use at their installations.\*

Most of the air curtains surveyed were unsatisfactory in excluding insects based on air stream velocity, angle of throw, thickness, and outlet width. Conditions and factors observed to be contributing to this ineffectiveness are described below.

1. Damaged or inoperable units. Some of the air curtains surveyed had been partially damaged or were inoperable, but had not been serviced. In a few instances, air curtains were operating ineffectively or were unsafe because of damage sustained from improper maintenance or lack of maintenance.

2. Negative pressure. Mechanical exhaust and ventilation in most of the facilities visited created a mechanical negative pressure condition in the interior of the building that drastically decreased the effectiveness of the air curtain machines. Negative pressure in the building tends to induce a horizontal flow into the building.

3. Installation. It was observed that air curtains installed inside doorways brought in dust, debris, and small insects at floor level because of short circuiting of the air current and improper directional damper settings (Figures 4 through 6). Some of the units were installed too high above the top of the door frame, making the air stream too weak to effectively expel small flying insects from the doorway (Figure 7a). Some of the units did not provide full-width coverage at the top of door (Figures 7b and c).

4. Maintenance. Most air curtain manufacturers claim that their products are maintenance-free. It

\*Electronic fly control devices may be used in Air Force facilities away from food preparation and serving areas, per Letter, Chief, USAF Veterinary Services Division, Subject: Electronic Fly Control Devices (2 October 1975).

was observed, however, that the inlets, outlets, and motors of all units installed in kitchen areas were thickly coated with grease, which contributed to decreased fan efficiency and, in certain cases, resulted in motor burn-up due to motor overheating. In one location, a bird's nest was found in the discharge outlet.

5. Wind conditions. Some air curtain machines observed were unable to stop the wind, a prerequisite for preventing insects from entering a building. No guidance exists on accommodating local wind conditions when selecting an air curtain machine for fly control.

6. Accessibility of air curtain machine's ON/OFF switch. Air curtains' ON/OFF switches were found to be accessible to unauthorized personnel who could turn the units off when they should have been in operation.

7. Improperly sized air curtain machines. Most installed units have discharge outlets shorter than the widths of the door openings, as observed in previous Air Force studies.<sup>12</sup> In addition, most of these units do not have a directional adjustment for the angle of throw. They do, however, have directional adjustments to divert the air stream sideways, thus providing full "air stream" coverage above the door opening.

8. Weak spots in the air stream. Some of the units surveyed had weak spots in the air stream at the discharge outlet which had inadequate air stream velocity.

9. Air curtain machines for patron doorways. No separate air curtain velocity requirements exist in Federal Specifications for patron entrances and exits. With the present velocity requirements, the air curtains are very annoying to patrons. National Sanitation Foundation (NSF) Standard No. 37<sup>13</sup> recommends a separate air stream requirement for patron entrances and exits.

<sup>12</sup>Letter, HQ, Air Force Logistics Command, DPS, Subject: Air Curtain Survey (11 October 1974), with inclosure, HQ, Air Force Logistics Command, SGV, Subject: Air Curtain Survey (2 October 1974); and Letter, HQ, SAC, Subject: Unsatisfactory Performance of AFSO Recommended Air Curtain (20 August 1975).

<sup>13</sup>*Air Curtains for Entranceways in Food Establishments*, Standard No. 37 (National Sanitation Foundation, 23 July 1970).

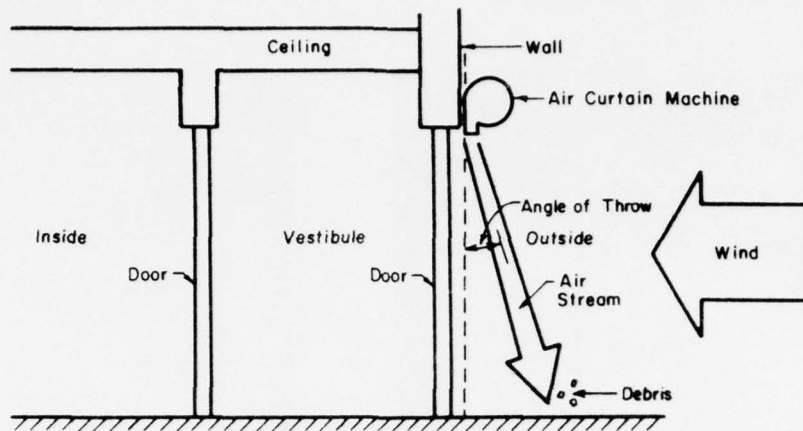


Figure 4. Proper installation of air curtain machine outside the premise for insect exclusion.

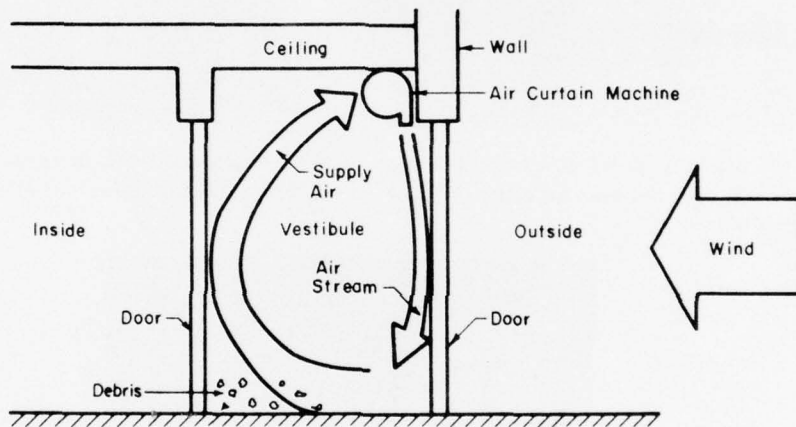


Figure 5. Improper installation of air curtain machine in vestibule for insect exclusion.

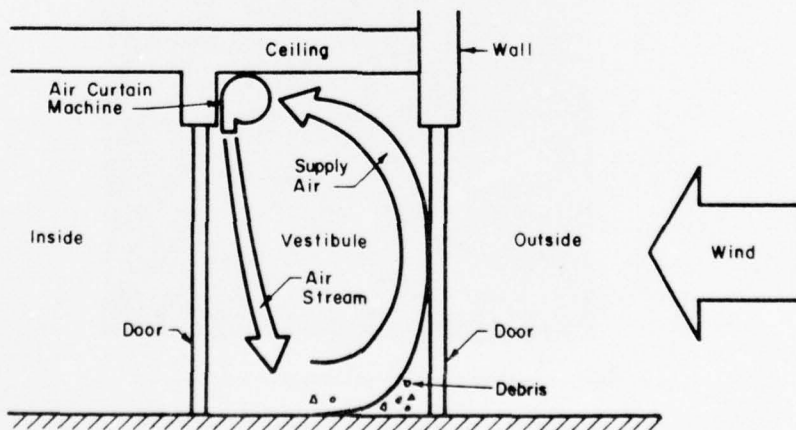


Figure 6. Proper installation of air curtain machine in vestibule for insect exclusion.



a. Air curtain machine installed 13 ft (3.96 m) above door and does not have an angle of throw of 15 degrees outward.



b. Air curtain machine does not provide continuous full-width coverage at top of door.



c. Same problem as b. Note damage to unit on right.

Figure 7. Improper installation of air curtain machines.

## 4 CONCLUSIONS AND RECOMMENDATIONS

### Conclusions

The field survey revealed that most of the air curtain machines in Army and Air Force installations have been ineffective in excluding small flying insects because of product deficiency and insufficient technical guidance. These problems have sometimes been compounded by improper equipment installation and maintenance. Proper design, installation, and maintenance of air curtain units can provide more effective insect exclusion. The following conclusions regarding design, installation, and maintenance were drawn based on this study:

1. Units must have proper discharge outlet length, exit velocity, and directional adjustment for angle of throw.
2. Local wind characteristics must be considered, and wind breakers should be used to alleviate local wind problems.
3. Building pressure balance must be designed to maintain proper (neutral) pressure in the building.
4. A thicker air jet at lower velocity is more effective than a thinner jet at higher velocity.
5. Units must be installed near the top of the door frame and outside the space the air curtain is to protect.
6. Air curtain units must receive regular preventive maintenance and be checked for proper adjustment to exclude flying insects on a continuing basis.

### Recommendations

The following recommendations are based on the results of this study:

1. Properly designed and installed air curtain machines should be used at doorways in food service facilities, commissaries, and subsistence warehouses where personnel traffic is high and installation of screen doors is not possible.
2. The design guidance presented in Appendix B should be implemented.

3. Federal Specification 00-B-1620, with the changes recommended in Appendix B, should be used for Army and Air Force air curtain machine procurement.

4. A study should be conducted to determine the effectiveness of electronic fly control devices as supplements to air curtain machines for fly exclusion.

### CITED REFERENCES

- Air Curtains for Entranceways in Food Establishments*, Standard No. 37 (National Sanitation Foundation, 23 July 1970).
- ASHRAE Handbook of Fundamentals* (American Society of Heating, Refrigerating, and Air Conditioning Engineers, 1972).
- Blower, Air Barrier*, Federal Specification 00-B-1620 (General Services Administration, 26 September 1973).
- Carrier Company: Handbook of Air Conditioning System Design* (McGraw-Hill Book Company, 1965).
- An Engineering Evaluation of Air Curtains at Doorways for Exclusion of Insects From Food Service Facilities*, Report IMSW-BEE-74-147 (Department of the Air Force, August 1974).
- Engineering Instructions, Commissary Store Construction Program*, FY 76 MCA and Surcharge Programs (Office of the Chief of Engineers, 20 May 1974).
- Fact Sheet MID-FE-1 (U.S. Department of Agriculture, 8 March 1963).
- Fan Engineering*, seventh edition (Buffalo Forge Company, 1970).
- Food Service Sanitation*, AFM 163-8 (Department of the Air Force, 23 February 1972).
- Kurk, E. J., "All About Air Entrance," *Air Engineering*, Vol 4, No. 6 (June 1962), pp 38-42, and Vol 4, No. 7 (July 1962), pp 39-40, 45.

Letter, Chief, USAF Veterinary Service Division, Subject: Electronic Fly Control Devices (2 October 1975).

Letter, HQ, Air Force Logistics Command, DPS, Subject: Air Curtain Survey (11 October 1974), with inclosure, HQ, Air Force Logistics Command, SGV, Subject: Air Curtain Survey (2 October 1974).

Letter, HQ, SAC, Subject: Unsatisfactory Performance of AFSSO Recommended Air Curtain (20 August 1975).

McElroy, G. E., *Air Flow at Discharge of Fan—Pipe Lines in Mines*. Report of Investigation, R. I. 3730 (U.S. Bureau of Mines, November 1943), p 19.

#### UNCITED REFERENCES

*Construction Criteria Manual*, DOD 4270.1-M (Department of Defense, 1 October 1972).

Dean, M. L., "Use of Down Draft Air Curtains," *Medical Service Digest*, Vol XXIV, No. X (October 1973), pp 34-36.

*Engineering Instructions, Enlisted Personnel Dining*

*Facilities, FY 77 MCA Program* (Office of the Chief of Engineers, 28 February 1975).

Enlisted Personnel Dining Facility Sketch Design Drawings and Equipment Lists (Department of the Army), Drawing number SK 36-05-137, sheets 1 through 36 (23 September 1974), Drawing number SK 36-05-139, sheets 1 through 16 (31 December 1974), and Drawing number SK 36-05-140, sheets 1 through 16 (31 December 1974).

*Flies of Public Health Importance and Their Control* (U.S. Department of Health, Education, and Welfare).

Herndon, Charles L., "The Closed Open Door," *Heating, Piping and Air Conditioning*, Vol 38 (May 1966), pp 105-8.

Hocking, B., "An Insect Proof Doorway," *Bulletin of Entomology Research*, Vol 51, No. 1 (1960), pp 135-144.

*Plant Energy Systems* (Power, 1967).

Willis, M., E. A. Smith, and H. F. Schoff, "Use of Air Barriers to Prevent Entrance of House Flies," *Journal of Economic Entomology*, Vol 63, No. 1 (February 1970), pp 29-31.

## APPENDIX A:

### SUMMARY OF MANUFACTURERS' DATA

Table A1 summarizes product data provided by air curtain machine manufacturers. The products are described briefly below.

#### Air Economy Corporation\*

Air Economy Corporation's L<sub>0</sub>-Dor machine, which is used for buildings such as post exchanges, commissaries, hospitals, schools, etc., is available in high and low velocity models. For the high velocity unit, it is important to specify the use of a 4 to 5 in. (101.6 to 127.0 mm) wide nozzle with a velocity of 1600 ft/min (487.7 m/min) at 3 ft (0.9 m) above the floor. For the low velocity unit, a nozzle width of 8 to 10 in. (203.2 to 254.0 mm) with a velocity of 600 ft/min (182.9 m/min) at 3 ft (0.9 m) above the floor should be specified.

#### Chase Industries, Inc.

The Chase fly screen units are made of 18-gage paintlock metal, doubly protected with gray mist preventive coating. Each motor has a double extended shaft operating two squirrel cage blower wheels and fan housings. The unit has no belts or pulleys to be maintained or wear out.

Directional controls in the 3 in. (76.2 mm) wide nozzle help control and direct air flow. The fly screen requires a minimum space of 14½ in. (0.37 m) in height and projects 11¼ in. (0.29 m) from the wall. Installation is simple; adjustable brackets require only four screws or other fastening devices to attach the unit to the wall.

#### Dynaforce Corporation

Dynaforce manufactures several air curtains for different applications. The standard unit covers the entire width of the doorway. The F I unit, which is designed for insect control, is of the nonrecirculating type. This unit should be installed on the inside of the doorway. The unit can be hung from the ceiling

\*Information on these manufacturers' products was inadequate to permit inclusion in Table A1.

with four ½-in. (12.7 mm) diameter steel rods. Ceiling suspension is recommended to prevent the machine from falling if a fork-lift truck strikes the wall.

#### King Company of Owatonna

King recommends that their air curtains used for insect control be installed on the outside of the doorway. A clear surface above the door is required to mount the unit. For maximum results, it is recommended that the bottom of the air curtain unit be positioned just above the top of the door frame. The unit's discharge outlet should be designed to cover the entire width of the doorway.

#### Mars Air Doors\*

The Mars Air Curtain needs only to be bolted to the wall with three fasteners and connected to an electrical power source. Adjustable volumetric damper controls are provided to regulate the rate of air flow.

Mars' CH models are recommended for normal insect control conditions which exist at receiving doors in commissaries, post exchanges, restaurants, hospitals, etc.

#### Nieco Division, NPI Corporation

Nieco manufactures three series of air curtains:

1. The LTV Series of air curtain units is designed for industrial applications (8 to 10 ft [2.4 to 3.0 m] high doors) where insect or wind protection is important. The units are built for outdoor installation, with practically no maintenance required according to the manufacturer.

2. The MTV Series is designed for the same purpose as the LTV series, but has different discharge velocities.

3. The HTV Series gives three types of Nieco air screens. No information on installation of the equipment is available for this series of units.

\*Information on these manufacturers' products was inadequate to permit inclusion in Table A1.

Table A1  
 Tabulation of Manufacturers' Product Data

Company	Model No. or Series	Volumetric Control	Directional Control	Width, in. (m)	Discharge Velocity at Outlet, ft/min (m/min)	Thickness of Air Stream at Outlet, in. (mm)	Motor hp (W) at Rated rpm	No. of Motor	Comments		
Chase*	EHV-38	NA	NA	38 (0.9)	4500 (1372)	~2 1/2 (63.5)	1 1/2 (1118)	1	EHV models for fly-insect and dust control. For doors 8 to 11 ft (2.4 to 3.4 m) high.		
	EHV-48	NA	NA	48 (1.2)	3850 (1173)	~2 1/2 (59.3)	1 1/2 (1118)	1			
	EHV-60	NA	NA	60 (1.5)	4200 (1280)	~2 1/2 (63.5)	3 (2237)	1			
	EHV-84	NA	NA	84 (2.1)	4925 (1501)	~2 (50.1)	1 1/2 (1118)	2			
	EHV-108	NA	NA	108 (2.7)	4600 (1402)	~1 3/4 (44.5)	1 1/2 (1118)	2			
	EHV-132	NA	NA	132 (3.4)	5200 (1585)	~1 3/4 (47.6)	1 1/2 (1118)	3			
	Chase*	EHH-38	NA	NA	38 (0.9)	6000 (1829)	~2 3/4 (66.7)	3 (2237)		1	EHH models for fly-insect and dust control or where excessive draft conditions (over 15 mph [24 km/hr]) exist. For doors 11 to 16 ft (2.4 to 4.9 m) high.
		EHH-48	NA	NA	48 (1.2)	5200 (1585)	~2 1/2 (63.5)	3 (2237)		1	
		EHH-84	NA	NA	84 (2.0)	6250 (1905)	~2 1/2 (59.3)	3 (2237)		2	
EHH-108		NA	NA	108 (2.7)	5900 (1798)	~1 7/8 (47.8)	3 (2237)	2			
EHH-132		NA	NA	132 (3.4)	6700 (2042)	~2 (50.1)	3 (2237)	3			
Dynaforce	R Series	Yes	Single Deflection	36 (0.9)	1500 to 3000 (457 to 914)	2 1/4 (57.2)	3/4 (559)	1	R series used for light-duty control of insects.		
				48 (1.2)	1500 to 3000 (457 to 914)	2 1/4 (57.2)	3/4 (559)	1			
				60 (1.5)	1500 to 3000 (457 to 914)	2 1/4 (57.2)	3/4 (559)	2			
				72 (1.8)	1500 to 3000 (457 to 914)	2 1/4 (57.2)	3/4 (559)	2			
				84 (2.1)	1500 to 3000 (457 to 914)	2 1/4 (57.2)	3/4 (559)	2			
				96 (2.4)	1500 to 3000 (457 to 914)	2 1/4 (57.2)	3/4 (559)	2			
				120 (3.0)	1500 to 3000 (457 to 914)	2 1/4 (57.2)	3/4 (559)	3			
				144 (3.7)	1500 to 3000 (457 to 914)	2 1/4 (57.2)	3/4 (559)	3			
	F/I Series		No	Single Deflection	36 (0.9)	4000 (1219)	4 1/2 (114.3)	2 (1491)		1	F/I series is designed for insect control at loading docks. Has a higher sound level than the R series.
					48 (1.2)	4000 (1219)	4 1/2 (114.3)	2 (1491)		1	
					60 (1.5)	4000 (1219)	4 1/2 (114.3)	2 (1491)		2	
					72 (1.8)	4000 (1219)	4 1/2 (114.3)	2 (1491)		2	
					96 (2.4)	4000 (1219)	4 1/2 (114.3)	2 (1491)		2	
					108 (2.7)	4000 (1219)	4 1/2 (114.3)	2 (1491)		2	
				120 (3.0)	4000 (1219)	4 1/2 (114.3)	2 (1491)	2			
R&E Series		No	Single Deflection	36 (0.9)	1750 to 3500 (633 to 1067)	2 1/2 (63.5)	3/4 (559)	1	R series for light duty temperature separation. E series contains a heating coil.		

\*Thickness,  $H_0$ , determined by:  $\text{Area} = H_0 L$   $H_0 = Q/LV_0$

Table A1 (cont'd)

Company	Model No. or Series	Volumetric Control	Directional Control	Width, in. (m)	Discharge Velocity at Outlet, ft./min (m./min)	Thickness of Air Stream at Outlet, in. (mm)	Motor hp (W) at Rated rpm	No. of Motor	Comments									
Dynaforce	H Series	Yes	Double Deflection	60 (1.5)	3000 to 6000 (914 to 1829)	4 1/2 (114.3)	S(NOM)(3728)	1	This series is used for doors over 10 ft (3.0 m). At 14 ft (4.3 m), door can stop wind of 18.5 mph (29.6 km/hr); at 12 ft (3.9 m), door can stop wind of 22.0 mph (35.2 km/hr); at 10 ft (3.0 m), door can stop wind of 24.0 mph (38.9 km/hr).									
				96 (2.4)	3000 to 6000 (914 to 1829)	4 1/2 (114.3)	S(NOM)(3728)	2										
				108 (2.7)	3000 to 6000 (914 to 1829)	4 1/2 (114.3)	S(NOM)(3728)	2										
				120 (3.0)	3000 to 6000 (914 to 1829)	4 1/2 (114.3)	S(NOM)(3728)	2										
				144 (3.7)	3000 to 6000 (914 to 1829)	4 1/2 (114.3)	S(NOM)(3728)	3										
				156 (4.0)	3000 to 6000 (914 to 1829)	4 1/2 (114.3)	S(NOM)(3728)	3										
				164 (4.2)	3000 to 6000 (914 to 1829)	4 1/2 (114.3)	S(NOM)(3728)	3										
King Air Curtains	I Series	Yes	Double Deflection	48 (1.2)	2000 to 4000 (610 to 1219)	4 1/2 (114.3)	2(NOM)(1491)	1	I series is used at loading dock applications. At 10 ft (3.0 m), door can stop wind of 15.0 mph (24.0 km/hr); at 8 ft (2.4 m), door can stop wind of 18.0 mph (28.8 km/hr); at 6 ft (1.8 m), door can stop wind of 22.0 mph (35.2 km/hr).									
				60 (1.5)	2000 to 4000 (610 to 1219)	4 1/2 (114.3)	2(NOM)(1491)	1										
				72 (1.8)	2000 to 4000 (610 to 1219)	4 1/2 (114.3)	2(NOM)(1491)	2										
				96 (2.4)	2000 to 4000 (610 to 1219)	4 1/2 (114.3)	2(NOM)(1491)	2										
				108 (2.7)	2000 to 4000 (610 to 1219)	4 1/2 (114.3)	2(NOM)(1491)	2										
				120 (3.0)	2000 to 4000 (610 to 1219)	4 1/2 (114.3)	2(NOM)(1491)	2										
				144 (3.7)	2000 to 4000 (610 to 1219)	4 1/2 (114.3)	2(NOM)(1491)	3										
	Standard	2-25	Yes	Double Deflection	24 (0.6)	100 to 3700 (305 to 1125)	7 1/2 (190.5)	1/3	1	The standard series is used for thermal or insect barriers for doors of 8 ft (2.4 m). No definite thickness at outlet could be found.								
					3-75	Yes	20° Range Each Side of Vertical	36 (0.9)	100 to 3700 (305 to 1125)		7 1/2 (190.5)	1/3 (1750)	1					
								4-100	Yes		20° Range Each Side of Vertical	48 (1.2)	100 to 3700 (305 to 1125)	7 1/2 (190.5)	1	1		
												5-150	Yes	20° Range Each Side of Vertical	60 (1.5)	100 to 3700 (305 to 1125)	7 1/2 (190.5)	1 1/2
								6-150	Yes		20° Range Each Side of Vertical				72 (1.8)	100 to 3700 (305 to 1125)	7 1/2 (190.5)	1 1/2
												Super	S-4-200	Yes	Double Deflection	48 (1.2)	NA*	NA
								S-5-300	Yes		20° Range					60 (1.5)	NA	NA
S-6-300	Yes	20° Range	72 (1.8)	NA	NA	3 (2237)	1											

\*NA: Information not available.

Table AI (cont'd)

Company	Model No. or Series	Volumetric Control	Directional Control	Width, in. (m)	Discharge Velocity at Outlet, ft/min (m/min)	Thickness of Air Stream at Outlet, in. (mm)	Motor hp (W) at Rated rpm	No. of Motor	Comments
King Air Curtains	Super XH XH-6-500	Yes	Double Deflection	72 (1.8)	NA	NA	5 (3728)	1	Industrial air curtains, for doors up to 20 ft (6 m).
	XH-8-600	Yes	20° Range	96 (2.4)	NA	NA	7½ (5593)	1	
NIECO	LTV-40	NA	Yes	40 (1.0)	NA	NA	½ (249)	2	For use on doors 10 ft (3 m) high. Industrial applications for insect and wind protection.
	LTV-60	NA	Yes	60 (1.5)	NA	NA	½ (249)	3	
	LTV-48	NA	Yes	48 (1.2)	NA	NA	½ (249)	2	
	LTV-72	NA	Yes	72 (1.8)	NA	NA	½ (249)	3	For use on doors 8 ft high (2.4 m). Industrial applications for insect and wind protection.
NIECO	HTV-40	NA	Yes	40 (1.0)	NA	NA	1 (746)	2	For use on door up to 18 ft (5.4 m) high. All NIECO Air Screens have two vent design.
	HTV-60	NA	Yes	60 (1.5)	NA	NA	1 (746)	3	
	HTV-80	NA	Yes	80 (2.1)	NA	NA	1 (746)	4	
	HTV-100	NA	Yes	100 (2.5)	NA	NA	1 (746)	5	HTV series have two ~3½ in. (77.5 mm) outlet streams.
NIECO	MTV-40	NA	Yes	40 (1.0)	NA	NA	½ (249)	2	For use on doors up to 14 ft (4.3 m) high. Twin vent design.
	MTV-60	NA	Yes	60 (1.5)	NA	NA	½ (249)	3	
	MTV-80	NA	Yes	80 (2.0)	NA	NA	½ (249)	4	
	MTV-100	NA	Yes	100 (2.5)	NA	NA	½ (249)	5	

## APPENDIX B:

### RECOMMENDED DESIGN GUIDANCE AND CHANGES TO EXISTING SPECIFICATIONS

#### Design Guidance

1. All air curtain machines for fly control should be installed on the outside of doors opening to spaces where fly control is intended.

2. Air curtain machines should have a directional adjustment for the angle of throw that will permit the air barrier to be directed at angles of 15 to 20 degrees off the vertical center and toward the outside of the opening. Proper markings for the angle setting should be indicated on the machine's casing. A fail-safe device should be built into the machine to return the angle of throw to 15 degrees.

3. Turning vanes should be used in air curtain machines whenever abrupt changes in air flow direction are involved.

4. A pressurizing box should be used in air curtain machines to produce a uniform outlet velocity.

5. For dining facility and commissary patron entrance doors up to 8 ft (2.4 m) high, air curtain units should be installed, preferably in vestibules, on the outside of the doors. The air stream at the discharge outlet must be at least 8 in. (203.2 mm) thick and be able to maintain a minimum uniform outlet velocity of 1200 ft/min (366 m/min).

6. For a service door up to 8 ft (2.4 m) high, the air stream should be adjusted for local wind conditions\* as follows:

a. Light local wind conditions: minimum outlet air velocity and thickness should be 2800 ft/min (853 m/min) and 4½ in. (114.3 mm); minimum uniform velocity 3 ft (0.9 m) above the floor should be 1600 ft/min (488 m/min).

b. Moderate local wind conditions: minimum outlet air velocity and thickness should be 3000 ft/min (814 m/min) and 4½ in. (114.3 mm); minimum uniform velocity 3 ft (0.9 m) above the floor should be 1800 ft/min (549 m/min).

c. High local wind conditions: minimum outlet air velocity and thickness should be 3000 ft/min (814 m/min) and 6 in. (152.4 mm); minimum uniform velocity 3 ft (0.9 m) above the floor should be 2000 ft/min (610 m/min).

7. For 10- to 12-ft (3.0 to 3.7 m) high door openings to subsistence warehouses exposed to the outside, the air stream should be adjusted for various local wind conditions as follows:

a. Light local wind conditions: minimum outlet velocity and air thickness should be 3200 ft/min (975 m/min) and 6 in. (152.4 mm); uniform velocity 3 ft (0.9 m) above the floor should be 1600 ft/min (488 m/min).

b. Moderate local wind conditions: minimum outlet velocity and air thickness should be 3500 ft/min (1067 m/min) and 6 in. (152.4 mm); uniform velocity at 3 ft (0.9 m) above the floor should be 1800 ft/min (549 m/min).

c. High local wind conditions: minimum outlet air velocity and thickness should be 4000 ft/min (1213 m/min) and 6 in. (152.4 mm); minimum uniform velocity at 3 ft (0.9 m) above the floor should be 2000 ft/min (610 m/min).

8. Key-operated air curtain machine switches should be installed to prevent unauthorized personnel from turning off air curtain units.

9. Devices should be installed to activate/deactivate the air curtain units for overhead doors before/after the doors have been raised/closed.

10. If a negative pressure exists in the building, modifications must be provided to allow make-up air to enter the building.

11. Where possible, a 3 to 6 in. (76.2 to 152.4 mm) overlap on each side of the door should be provided.

#### Changes to Existing Specification

The following sections of Federal Specification 00-B-1620 should be modified:

1. Section 3.5.2 should be modified to specify that for insect control, the angle of throw is to be directed toward the outside of the area to be protected.

\*Wind conditions defined in the 1972 ASHRAE Handbook of Fundamentals, Table 1, Chapter 33.

2. Section 3.5.5 should be modified to specify that no directional adjustment vanes should be provided for any directional adjustment other than the angle of throw in all air curtain machines for insect exclusion.

In addition, this section should specify that the discharge nozzle of the air curtain unit or a multiple installation should be at least as wide as the entryway and should provide continuous uniform air stream coverage at the top of the entryway to be protected.

3. In Section 3.8, the words "and the air stream shall be at least 2 inches wide" should be deleted. In addition, a requirement for patron entryway should be included.

4. In Section 4.3.3, the words "four feet wide and seven feet high" should be deleted.

5. Section 4.3.6 should indicate that the thickness of the air stream is to be measured at the air curtain

unit discharge outlet. Paragraphs 2, 3, and 4 of this section should be modified as follows:

a. Paragraph 2 should be modified to specify that measurements are to be taken at 6-in. (152.4 mm) intervals with the first and last measurements to be taken at each side of the door opening. In addition, a sweeping velocity measurement at the outlet of the air curtain machine should be taken to assure a continuous uniform air stream at the outlet.

b. Paragraph 3 should be modified to include a minimum outlet velocity requirement for air curtain unit for patron entryways.

c. Paragraph 4 should be modified to include hot-wire anemometer.

6. In Section 6.1, the sentence "The air barriers specifically covered by this specification are intended for an opening four feet wide by seven feet high but the options provide for specifying other size openings" should be deleted.

APPENDIX C:

FEDERAL SPECIFICATION 00-B-1620

00-B-1620  
September 26, 1973  
SUPERSEDING  
INT. FED. SPEC. W-F-001350(GSA-FSS)  
March 15, 1968

FEDERAL SPECIFICATION

BLOWER, AIR BARRIER

This specification was approved by the Commissioner, Federal Supply Service, General Services Administration, for the use of all Federal agencies.

1. SCOPE AND CLASSIFICATION

1.1 Scope. This specification covers a nonpositive displacement mechanical device having an axial or centrifugal fan impeller inclosed within a housing with an exhaust nozzle and baffles. It is designed to move air across an open entrance to provide an air barrier to minimize heat loss or gain and repel flying insects.

1.2 Classification. Blower air barriers covered by this specification shall be of the following types (see 6.2).

Type I - Insect control.  
Type II - Thermal control.

2. APPLICABLE DOCUMENTS

2.1 The following documents, of the issues in effect on date of invitation for bids or request for proposal, form a part of this specification to the extent specified herein:

Federal Specifications:

PPP-B-591 - Boxes, Shipping, Fiberboard, Wood-Cleated.  
PPP-B-601 - Boxes, Wood, Cleated-Plywood.  
PPP-B-621 - Boxes, Wood, Nailed and Lock-Corner.  
PPP-B-640 - Boxes, Fiberboard, Corrugated, Triple-Wall.

Federal Standards:

Fed. Std. No. 123 - Marking for Domestic Shipment (Civil Agencies).

(Activities outside the Federal Government may obtain copies of Federal Specifications, Standards, and Handbooks as outlined under General Information in the Index of Federal Specifications and Standards and at the prices indicated in the Index. The Index, which includes cumulative monthly supplements as issued is for sale on a subscription basis by the Superintendent of Documents, U. S. Government Printing Office, Washington, DC 20402.

(Single copies of this specification and other Federal Specifications required by activities outside the Federal Government for bidding purposes are available without charge from Business Service Centers at the General Services Administration Regional Offices in Boston, New York, Washington, DC, Atlanta, Chicago, Kansas City, MO, Fort Worth, Denver, San Francisco, Los Angeles, and Seattle, WA.

(Federal Government activities may obtain copies of Federal Specifications, Standards, and Handbooks and the Index of Federal Specifications and Standards from established distribution points in their agencies.)

Military Specifications:

MIL-P-116 - Preservation, Methods of.

Military Standards:

MIL-STD-105 - Sampling Procedures and Tables for Inspection by Attributes.  
MIL-STD-129 - Marking for Shipment and Storage.  
MIL-STD-130 - Identification Marking of U. S. Military Property.

FSC 4140

(Copies of Military Specifications and Standards required by suppliers in connection with specific procurement functions should be obtained from the procuring activity or as directed by the contracting officer.)

2.2 Other publications. The following documents from a part of this specification to the extent specified herein. Unless a specific issue is identified, the issue in effect on date of invitation for bids or request for proposal shall apply.

Underwriters' Laboratories (UL) Inc. Standards:

No. 507 - Electric Fans.

(Application for copies should be addressed to the Underwriters' Laboratories, Inc., Walt Whitman Rd., Melville, L.I., N.Y. 11749; 333 Pfingsten Road, Box 247, Northbrook, IL. 60062; 1655 Scott Blvd., Santa Clara, CA. 95050; 2602 Tampa East Blvd., Tampa, FL. 33619; or 207 East Ohio St., Chicago, IL. 60611.)

National Electrical Manufacturers Association (NEMA) Publications:

No. MG1 - Motors and Generators

(Application for copies should be addressed to the National Electrical Manufacturers Association, 155 East 44th Street, New York, N.Y. 10017.)

National Motor Freight Traffic Association, Inc., Agent:

National Motor Freight Classification.

(Application for copies should be addressed to the American Trucking Association, Inc., Tariff Order Section, 1616 P Street, N.W., Washington, DC 20036.)

Uniform Classification Committee, Agent:

Uniform Freight Classification.

(Application for copies should be addressed to the Uniform Classification Committee, Room 1106, 222 South Riverside Plaza, Chicago, IL 60606.)

American National Standards Institute, Inc., (ANSI) Standard:

S1.4 - 1961 - General Purpose Sound Level Meters.

(Application for copies should be addressed to the American National Standards Institute, Inc., 1430 Broadway, New York, N.Y. 10018.)

3. REQUIREMENTS

3.1 Bid and preproduction samples.

3.1.1 Bid sample. A bid sample shall be submitted for inspection as specified in the Invitation for Bids to determine compliance with subjective requirements not covered by a specific test in Section 4.3 or referenced specifications.

3.1.2 Preproduction sample. Unless otherwise specified (see 6.2), before production is commenced, a complete Blower, Air Barrier covered by this specification shall be submitted or made available to the contracting officer or his authorized representative for approval in accordance with 4.3.1. Approval of the preproduction sample authorizes the commencement of production but does not relieve the supplier of responsibility for compliance with all applicable provisions of this specification. The preproduction sample shall be manufactured in the same facilities to be used for the manufacture of the production items.

3.1.2.1 Waiver of preproduction sample tests. Preproduction sample tests may be waived provided the contracting officer finds that the model offered by the contractor is equal to or superior in quality and performance and meets all the requirements of this specification. This determination may be made by visual examination or by comparison of component parts, bills of materials, or drawings of a model previously found acceptable on a Government contract, provided the contractor furnishes copies of certified test data covering previous tests of this model to the contracting officer. The test data must indicate compliance with the specified test conditions and must have been obtained as a result of tests conducted within the past 4 years on an identical type blower air barrier furnished on a Government contract. In addition to test data, a certified statement to the effect that the blower air barriers being furnished are identical with those previously tested will be required.

### 3.2 Fire and casualty hazards.

3.2.1 Each supplier shall submit to the contracting agency proof that the blower air barrier he proposes to supply under this specification conforms to the requirements of the Underwriters' Laboratories, Inc., UL Standard 507, as applicable. The UL Label, or listing mark will be accepted as evidence that the blower air barrier conforms to these requirements.

3.2.2 In lieu of the label, or listing mark, the contractor may submit independent proof, satisfactory to the contracting agency, that the blower air barrier conforms to the applicable requirements of the published standard including methods of tests of the Underwriters' Laboratories Standard 507.

3.2.3 Compliance with the above preliminary requirements in regard to fire and casualty hazards does not absolve the contractor from compliance with the other requirements of this specification in order to secure acceptance of his material or appliance.

3.3 Material. All material used in the blower, air barrier shall be new, have smooth even surfaces and shall be free of any defects that may affect its serviceability or its appearance.

3.4 Construction. The design and fabrication of the blower air barrier shall be such as to minimize the retention of moisture and dust and to facilitate inspection, servicing, maintenance and cleaning. All air blowers shall be complete and assembled electric motor driven machines. The material shall be of sufficient thickness, adequately reinforced and insulated to eliminate excessive noise and vibration. All joints and seams shall be closed except that joints may be made by overlapping sheets of metal in a vertical plane in such a manner as to eliminate dirt-catching horizontal edges. Electrical wiring to the motor(s) shall be adequately insulated and anchored to prevent contact with the fan blade assembly. Unless otherwise specified (see 6.2), the wiring shall terminate in a junction box mounted on an outside surface of the air barrier, and shall be suitable for outdoor use.

### 3.5 Component parts.

3.5.1 General. The blower air barrier shall essentially consist of a housing, plenum, one or more electric motors, fan blade assembly or assemblies, discharge nozzle, and other parts not specifically mentioned but which are essential to form a complete assembled operating unit.

3.5.2 Housing. Unless a specific location is specified (see 6.2), the housing shall have air intake parts on one end, both ends, top or front. All air intake openings shall be protected by a screen having openings no greater than 3/4 inch minimum dimension and when the guard is lower than 7 feet from the floor, the minimum opening shall be no greater than 1/2 inch. An adjustment feature shall be included that will permit the air barrier to be directed at angles of 15 to 20 degrees off the vertical center of the opening.

3.5.3 Motors. Motors shall conform to the requirements of NEMA Standard Publication No. MG 1. Motors shall have adequate starting torque to start the fan and shall be capable of operating the fan continuously under maximum load without exceeding the maximum allowable temperature rise specified in UL Standard 507.

3.5.3.1 Bearings. Bearings shall be ball, sleeve, or spherical sleeve type. They shall be of the maintenance free permanent lubrication type.

3.5.4 Fan blade assembly. The fan blade assembly or assemblies shall be mounted directly on the motor shaft or may be belt driven. They shall be of a design and size that will adequately move the required volume of air necessary to meet the air velocity requirements (see 3.8).

3.5.4.1 Fan balance-vibrations. The rotating components of the type I and II blower air barriers shall be balanced to the extent that the total vibration in both the horizontal and vertical planes does not exceed the vibration levels of 0.02 inch (see 4.3.4).

3.5.5 Discharge nozzle. The discharge nozzle shall extend the full width of an opening (four feet wide) enabling the air stream to cover the entire opening. There shall be adjustable vanes to control the directional air flow.

3.6 Performance. Unless a different size opening is specified (see 6.2), blower air barriers furnished under this specification shall be capable of providing an air barrier at the specified velocities (see 3.8) over the entire area of an opening four feet wide by seven feet high. The air barrier shall be designed to produce full air movement instantly when the motor is switched on.

3.7 Noise level. The noise level of the blower air barrier at maximum speed, shall not exceed 75 dbA (see 4.3.5).

3.8 Velocity. The velocity of the air barriers shall be measured in feet per minute (f.p.m.) when subjected to the test specified in 4.3.6 and the air stream shall be at least 2 inches wide.

3.8.1 Type I. Shall have a minimum air stream velocity of 1600 f.p.m. measured at points 3 feet above the floor.

3.8.2 Type II. Shall have a minimum air stream velocity of 600 f.p.m. measured at points 3 feet above the floor.

3.9 Instruction manual. An instruction manual shall be furnished with each blower air barrier that clearly instructs the user on the proper installation procedures, operation and maintenance.

3.10 Finish. The finish shall be of the manufacturer's standard practice.

3.11 Marking for identification.

3.11.1 Military agencies. The blower air barriers shall be marked in accordance with MIL-STD-130.

3.11.2 Civil agencies. The blower air barriers shall be marked with the name of the manufacturer, contract number and date.

3.12 Workmanship. The finished blower air barrier shall be clean and conform to the quality and grade of the products established by this specification. All burrs, rough and sharp edges shall be removed. All exposed welds or seams shall be ground smooth. There shall be no flaking, peeling or chipping of paint or any exposure of bare metal. All bolt and rivet holes shall be accurately and cleanly punched or drilled and rivet heads neatly finished. In general, the blower air barrier shall be free from any defects that affect appearance and serviceability and any defects that may cause injury to the user.

#### 4. QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for inspection. Unless otherwise specified in the contract or purchase order, the supplier is responsible for the performance of all inspection requirements as specified herein. Except as otherwise specified, the supplier may utilize his own facilities or any commercial laboratory acceptable to the government. The Government reserves the right to perform any of the inspections set forth in the specification where such inspections are deemed necessary to assure that supplies and services conform to prescribed requirements.

4.2 Sampling for inspection and acceptance. Sampling for inspection and acceptance shall be made in accordance with the provisions set forth in MIL-STD-105, except where otherwise indicated herein.

4.2.1 Inspection of components and materials. In accordance with 4.1, the supplier is responsible for insuring that components and materials used were manufactured, tested and inspected in accordance with the specified requirements of reference subsidiary specifications and standards, or if none, in accordance with this specification.

4.2.2 End product inspection. All blower air barriers of the same type offered for acceptance at one time shall be considered a lot for the purpose of inspection. The sample unit for these inspections shall be one completely fabricated blower air barrier.

4.2.2.1 Visual examination. The completely assembled end item shall be examined for defects in finish, construction, workmanship, and marking. All instances of nonconformance shall be considered as a defect and classified as affecting serviceability, or not affecting serviceability of the air barrier. Acceptable quality levels (AQL) 1.5 and 4.0 defects per hundred units respectively, shall be used to determine whether or not the number of defects warrants rejection of the entire lot.

Examine	Defect	Major	Minor
Finish	Not finished as required.		X
Design	Any characteristic not in accordance with the specified requirements.	X	
Construction and Workmanship general (applicable to all components and assemblies)	Fractured, split, bowed, malformed, or otherwise impaired.	X	
	Sharp burrs, splinters, or splinters that may be injurious to personnel.	X	
Assembly	Not properly assembled or secured.	X	
Marking identification	Missing, incomplete, not legible, not as specified.		X

4.2.2.2 Sampling for test. A random sample of air barriers shall be selected from each lot offered for acceptance. The sample size shall be in accordance with level S-2 of MIL-STD-105 with an AQL of 4.0 defects expressed in defects per hundred units.

4.2.3 Code and standards compliance. The contractor shall provide the Government representative with proof of compliance with the Underwriters' Laboratories requirements of 3.2.

#### 4.3 Tests.

4.3.1 Preproduction sample tests. Preproduction sample tests shall consist of all tests specified or described under 4.3 of this specification.

4.3.1.2 Place of preproduction sample tests. Preproduction sample tests shall be conducted at a Government laboratory designated by the Standardization Division, Federal Supply Service, General Services Administration or upon approval by Standardization Division, Federal Supply Service, tests may be conducted at a commercial laboratory, or at the manufacturer's plant.

4.3.2 Lot acceptance test. Unless otherwise specified, the contractor shall furnish all samples and shall be responsible for accomplishing the required tests. Testing if conducted at the contractor's plant, shall be under the supervision of the Government inspector. Suppliers not having laboratory testing facilities satisfactory to the Government shall engage the services of a commercial testing laboratory acceptable to the Government. Unless otherwise indicated, lot acceptance tests shall include all tests specified or described under 4.3.

4.3.2.1 Failure of any sample on any test shall be cause for rejection of the lot represented by the sample.

4.3.3 Performance tests. Tests as specified or described under 4.3.4 to 4.3.6 inclusive, shall be conducted at rated voltage and frequency of the blower air barrier. The following tests shall be conducted with the blower air barrier mounted over an opening four feet wide and seven feet high.

4.3.4 Fan balance-vibrations. The fan balance is indicated by measuring the vibration level of the blower air barrier when in operation. Procedures are as follows:

1. Start the unit in operation, observe and record the readings. Any of which exceed 0.02 inch shall be cause for failure.
2. A minimum of 5 readings randomly selected by the government representative shall be taken on the exterior surface area of the blower air barrier.
3. The vibration measurements shall be made with a Bruel and Kjaer impulse precision sound level meter type 2204 with integrator type ZR0020 and accelerometer type 4332 or equivalent. Frequency range is between 5 and 4000 Hz.

4.3.4.1 If acceptable to the government, an alternate method for determining vibration movement may be utilized in lieu of the procedure specified in 4.3.4.

4.3.5 Noise measurements. Noise measurements shall be made with a sound level meter conforming to ANSI Standard S1.4 with the blower operating at maximum speed. Procedures are as follows:

1. Locate the microphone on a tripod 3.5 feet above the floor and ten feet away from the front and center of the blower.
2. Connect the sound level meter to the microphone and locate it at least 3 feet back of the microphone so as not to induce any reflectance from the operator.
3. The increase in the sound pressure level with the sound source (blower) operating, compared to the ambient sound pressure level above, (without blower) shall be 10 dBA slow or more.
4. Start the blower in operation and run for a period of not less than five minutes before taking any readings.
5. A minimum of three readings shall be taken. One at the ten foot distance from the center and in front of the blower and one reading 5 foot each side of the center reading in the same plane. If the average of the three readings exceeds 75 dBA, it shall be cause for failure.

4.3.6 Velocity. Air velocity measurements are to be made with the blower air barrier operating at the designed speed. The air stream must cover the entire opening and shall be not less than 2-inches wide to assure a satisfactory barrier. Procedures are as follows:

1. Start the blower air barrier in operation and run for at least five minutes before taking any readings.
2. Five measurements are to be taken at the 3-foot level evenly distributed from one side to the other of the opening. Also readings shall be taken six inches from the upper corners of the opening to assure complete air stream coverage of the opening.
3. For the type I, unit; any reading less than 1600 FPM or the type II unit any reading less than 600 FPM shall be cause for failure.
4. The instrumentation to be used shall be the rotating vane anemometer, Weather Measure Corporation Model W-132 or equivalent.

4.3.7 Inspection of preparation for delivery. An inspection shall be made to determine that the preservation, packing, and marking comply with the requirements in section 5 of this specification. Defects shall be scored in accordance with table I. The sample shall be one shipping container fully prepared for delivery. The lot size shall be the number of shipping containers in the end item inspection lot. Sampling shall be in accordance with MIL-STD-105, inspection level S-2, and the AQL shall be 4.0 defects per hundred units.

TABLE I. Classification of defects

Examine	Defects
Preservation	Not as specified.
Containers	Not kind specified.
Workmanship	Inadequate application of components such as fan not properly braced in the box, incomplete closure of containers, loose strapping (when required) or distortion of container.
Marking	Omitted; incorrect; illegible; improper size, location, sequence, or method of application.

## 5. PREPARATION FOR DELIVERY

5.1 Cleaning and preservation. Cleaning and preservation shall be level A or C, as specified (see 6.2).

5.1.1 Level A. Each fan shall be cleaned by method C-1 of Mil-P-116 and preserved by method 11a of MIL-P-116.

5.1.2 Level C. Each fan shall be cleaned and preserved to prevent corrosion and deterioration during shipment from the supplier to the first receiving activity.

5.2 Packing. Packing shall be level A, B, or C, as specified (see 6.2).

5.2.1 Level A.

5.2.1.1 Fan without cabinet. Each fan without cabinet, preserved, as specified in 5.1.1, shall be packed in a fiberboard box conforming to PPP-B-640, class weather-resistant, style RSC-L. The preserved fan shall be secured to wood strips within the fiberboard box. The strip shall be positioned and braced to prevent the preserved fan from moving or exerting pressure against the sides, ends, and top of the box.

5.2.1.2 Fan with cabinet. Each fan, with cabinet, preserved, as specified in 5.1.1, shall be packed in a wood-created fiberboard, wood-created plywood, nailed wood, or fiberboard box conforming to PPP-B-591, class II; PPP-B-601, overseas type; PPP-B-621, class 2; or PPP-B-640, class 2, respectively. The preserved fan shall be secured to wood strips within the box. The strips shall be positioned and braced to prevent the fan from exerting pressure on the sides, ends, and top of the box.

5.2.2 Level B.

5.2.2.1 Fan without cabinet and fan with cabinet. Each fan, preserved, as specified in 5.1, shall be packed in a fiberboard box conforming to PPP-B-591, class domestic, style RSC-L. Blocking or bracing shall be provided to prevent movement of the fan within the box.

5.2.3 Level C. Each fan, packaged, as specified in 5.2, shall be packed to assure carrier acceptance and safe delivery to destination at lowest rates, in containers complying with the Uniform Freight Classification or National Motor Freight Classification Rules, as applicable.

5.3 Marking.

5.3.1 Civil agencies. In addition to any special markings required by the contract or order, each shipping container shall be marked in accordance with Fed. Std. No. 123.

5.3.2 Military agencies. In addition to any special markings required by the contract or order each shipping container shall be in accordance with MIL-STD-129.

## 6. NOTES

6.1 Intended use. These air barriers are intended to be used to provide an air barrier across opening or doorway to separate inside and outside air with different temperatures, or to prevent the entry of insects through the doorway when the door is open. The air barriers specifically covered by this specification are intended for an opening four feet wide by seven feet high but the options provide for specifying other size openings. Other options provide for specifying velocities and outward angling of the air curtain to counteract wind currents or pressure differentials. Also provided, are options for specifying location of intake ports when clearance is a critical factor.

6.2 Ordering data. Purchasers should select the preferred options permitted herein, and include the following information in procurement documents:

- (a) Title, number, and date of this specification.
- (b) Type of fan (see 1.2).
- (c) Wiring connection, if different (see 3.4).
- (d) Size of opening, if different (see 3.6).
- (e) When angle adjustment feature is required (see 3.5.2).
- (f) Location of intake ports, when required (see 3.5.2).
- (g) Minimum velocity of type I fans, when required (see 3.1).
- (h) Minimum velocity of type II fans, when required (see 3.8.2).
- (i) Level of preservation and packing required (see 5. and 5.2).
- (j) Whether reproduction sample is required (see 3.1.2).

6.3 It is believed that this specification, adequately describes the characteristics necessary to secure the desired material, and that normally no samples will be necessary prior to award to determine compliance with this specification if, for any particular purpose, samples with bids are necessary, they should be specifically asked for in the invitation for bids, and the particular purpose to be served by the bid sample should be definitely stated, the specification to apply in all other respects.

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