Design Guidelines for the Handling of Corrugated Containers/ Cut Sheets with Vacuum

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Technical Report for packaging machinery
prepared by Packaging Machinery Manufacturers Institute
and Fibre Box Association

DESIGN GUIDELINES FOR THE HANDLING OF CORRUGATED CONTAINERS / CUT SHEETS WITH VACUUM

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Technical Reports

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0. Foreword

This document is not an American National Standard and the material contained herein is not normative in nature. Comments on the content of this document should be sent to Director of Technical Services, Packaging Machinery Manufacturers Institute, 11911 Freedom Drive, Suite 600, Reston, VA 20190-5629 USA, or Fibre Box Association (FBA), 500 Park Boulevard, Suite 985, Itasca, IL 60143 USA.

This Technical Report was promulgated by the Packaging Machinery Manufacturers Institute (PMMI) in collaboration with the Fibre Box Association (FBA) as a voluntary Technical Report to establish guidelines for the handling systems, robotic systems, or packaging machines which move unfilled corrugated fiberboard containers/cut sheets by means of vacuum.

The information in this Technical Report was first published as a “voluntary guideline” in 1968. A revised version was released May 1989, July 2001 and July 2011.

Metric Policy - Dimensions and other units of measure will be given in English followed by metric (SI) units in parentheses (soft conversion from English to Metric units will be permitted (e.g.: 5¾ inches (14.6 cm)). “Soft Metric” means the result of mathematical conversion of inch-pound measurements to metric equivalents in specifications. The physical dimensions are not changed.[1]

1. Scope

1.1 Purpose

This Technical Report provides methods for optimizing the operation of packaging equipment that uses a vacuum apparatus to handle unfilled corrugated fiberboard materials, which shall be referred to in this document as fiberboard. The Fibre Box Association (FBA) and the Packaging Machinery Manufacturers Institute (PMMI) developed and adopted this Technical Report to enhance understanding between manufacturers and users of packaging equipment and fiberboard packaging. It does not include the handling of filled containers (see PMMI B155 TR1 for filled corrugated containers).

This Technical Report is entirely voluntary and is not intended to preclude the exercise of ingenuity in field application or inhibit the improvement in design or performance of corrugated fiberboard packaging or packaging equipment.

1.2 Scope

The guidelines of this Technical Report may be applied to new, existing, modified, or rebuilt industrial and commercial handling systems, or packaging machines which move unfilled corrugated fibreboard containers/cut sheets by means of vacuum. The focus of this Technical Report is the interaction of the above systems or machines, the vacuum system, and the corrugated fibreboard container.

This Technical Report does not consider the safety aspects of the industrial and commercial handling systems, robotic systems, or packaging machine. The informative references list the standards that should be used to evaluate the risks associated with the industrial and commercial handling systems, robotic systems, or packaging machines handling of filled corrugated or fibreboard containers with vacuum and how to use the risk assessment process to reduce those risks to an acceptable level.

1.3 Background

In the past, the focus was on the porosity of corrugated fiberboard with respect to inches of mercury ("Hg) as read from the gauge at the vacuum source. The actual volume of airflow at the vacuum cup has been given insufficient attention in the design and installation of the equipment. Appendix A describes an apparatus for measuring airflow at the vacuum cup.

For commercial operation of packaging equipment, vacuum source capacity is important to the performance of the equipment. However, the actual airflow volume at the vacuum cup is more significant than the "Hg gauge reading.

Attention should be focused on airflow volume at the point of contact between the vacuum cup and the corrugated fiberboard. Proper airflow volume is vital for satisfactory packaging equipment operation. The two most important factors that affect airflow in a given system are the design of the vacuum cup(s) and the piping arrangement.

1 U.S. General Services Administration Acquisition Manual Part 511.001 definitions

The holding force of the cup is related to the width of its annular sealing area. Vacuum cups that have an acceptable annular sealing area have proven most effective.

The piping arrangement used in packaging equipment is also vital to the operation and can diminish the rated airflow capacity of the vacuum source. Measuring packaging machinery in operation may reveal a wide difference between the rated capacity of the vacuum source and the actual airflow at the vacuum cup (see Appendix A).

While the "Hg gauge at the vacuum source may give some indication of system performance it cannot be used to accurately evaluate the airflow of the entire system. In addition to having a vacuum source with adequate capacity, it is crucial to maintain airflow volume through lines of optimal diameter with minimal bends, and without kinks or obstructions. The amount of air pulled directly through the corrugated fiberboard sheet has less influence on the degree of holding force produced than air infiltration around the sealing area of the vacuum cup, due to different types of fibers, finishes, surface irregularities, warp, washboarding, etc. of the corrugated fiberboard.

2 Informative References

The following documents contain provisions or guidelines which constitute additional resources available to the user of this Technical Report. These American National Standards contain requirements the user of this Technical Report should be aware of regarding the safety requirements for packaging machinery and industrial robots. All standards are subject to revision, and parties to agreements based on this Technical Report are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below.

ANSI/PMMI B155.1-2006 *Safety Requirements for Packaging Machinery and Packaging-Related Converting Machinery*

Fibre Box Handbook (Corrugated industry reference standard)

TAPPI T460 *Air resistance of paper (Gurley Method)*

PMMI B155 TR2.1 - 2010 *Tolerances For Regular Slotted Containers (RSCs)*

PMMI B155 TR2.2 - 2010 *Tolerances For Scored And Slotted Corrugated Sheets*

3 Definitions

3.1
manufacturer - see Supplier

3.2
operator - any qualified person whose duties include starting, stopping or supporting the normal operation of industrial and commercial handling systems, robotic systems, or packaging machines.

3.3
packaging machinery - any machinery that is used to produce, decorate, identify, fill, weigh, inspect, close, or seal a container or package, or used to convey or coordinate the packaging functions, which must take place in sequence on a production line.

3.4
qualified person- an individual who understands, is trained on, and demonstrates competence with the construction, operation or maintenance of the machinery.

3.5
supplier - an individual, corporation, partnership or other legal entity or form of business who provides equipment, materials, or services. A supplier can be any of the following; the manufacturer; manufacturer's agent, representative or distributor; reseller; installer; modifier; rebuilder; or integrator. When the user provides any of the above equipment, materials or services, the user is considered a supplier

3.6
user- an entity that utilizes the machinery or related equipment.
Note: Under certain circumstances (i.e., acting as a builder, modifier, integrator), the user is a supplier.

4 Responsibilities

4.1 General

Suppliers and users have responsibilities for defining and achieving agreed upon performance for the handling systems, robotic systems, or packaging machines used to handle corrugated fibreboard containers with vacuum.

4.2 Qualified persons

Suppliers and users should involve qualified persons in the application of information contained in this Technical Report.

4.3 Specifications

The user should communicate their specific requirements as part of the system purchase. The supplier(s) and user should develop an agreed upon set of specifications suited to the location, application, and operation specifics of the system for the handling of corrugated fibreboard containers with vacuum.

The system design and performance are based on the agreed upon specifications. If changes to the specifications (application, material, container, location etc.) occur during the life cycle of the system, performance could be affected.

4.4 Operation and maintenance

The user should operate and maintain the system within the established operating limits and consistent with the supplier information for operation and maintenance. The user should establish and follow a program of periodic and regular inspection and maintenance to ensure that all parts, auxiliary machinery, adjustments and repair are in accordance with the supplier information for operation and maintenance.

4.5 Training of user's personnel

The user should ensure that qualified persons (supervisors, operators, and maintenance individuals) are trained in the proper installation, adjustment, operation and maintenance of the system. The training should follow the system supplier's information for operation and maintenance.

The user should monitor the system's operation and maintenance to ensure that any suspected training deficiencies are identified by noting improper operation or maintenance and corrected.

5 Guidelines for Vacuum Handling of Unfilled Corrugated Fibreboard Containers/Cut Sheets

5.1 General

Industry experience has shown that automatic packaging machines maintained to the following settings should perform satisfactorily with commercially available corrugated fiberboard.

5.2 Vacuum Capacity Parameters

Tests have shown for a 3" suction cup, one or more vacuum sources producing a minimum rating of 3 SCFM at each suction cup when tested with remaining system cups sealed against applicable packaging material should be acceptable for most feeding applications.

5.3 Porosity of Corrugated Fiberboard

Porosity of the corrugated linerboard should be a minimum of 10 seconds (Gurley Units) per TAPPI T460), assuming the vacuum system performs according to these guidelines.

5.4 Vacuum Cups

5.4.1 General

The annular sealing area in contact with the corrugated fiberboard surface should have a minimum radial width of 3/8" for cups up to 3.25 inches in diameter. Other cup designs may be used, but the rubber durometer and the radial width of the annular sealing area should be as specified.

- Durometer should be approximately 40 - 50 shore A.
- Cups should have a minimum 5/16" I.D. orifice.

5.4.2 Size

Larger cups have more holding force at lower vacuum levels. Larger cups have more leakage through the container surface and around the lip.

5.4.3 Shape
Shape can be determined by the package. Bellows type are more forgiving, i.e. may seal better, but give less horizontal force for shear handling. Cleats add resistance to sliding forces.

5.4.4 Other
- Material of construction (friction coefficient and wear), durometer (sealing and friction), and fitting size (restrictions) also determine characteristics.
- Suitable cups need to be selected that address the needs of stability, carrying capacity, available space, and forces on the cups need to be determined to have adequate capacity for safe handling and movement.

5.5 Vacuum Cups - Considerations regarding cup selection

5.5.1 Vacuum Level
Vacuum level should be determined by the forces necessary at the cup. Lower is preferable for reasons of leakage and faster evacuation time but should be at a minimum of 6 "Hg (6 inches of Mercury) for cup stability.

5.5.2 Flow at the cup
Handling corrugated container material will create leakage in the system. It is necessary to know what flow is required at the cup to maintain the minimum vacuum level. Due to different characteristics of different vacuum sources, the flow at the cup is a measurement that should be determined at the working vacuum level, and not just at atmospheric (cups open). This is dependent on the permeability of the material being handled and leakage around the annular sealing area and can be determined with testing.

5.5.3 Contact Surface Area
The contact surface area of the container(s) will determine what type of vacuum tooling to design. A single cup to multiple cups can be used per container. More cups are not always better. Although they can provide more holding power they may create more chances for leakage of the vacuum system. Multiple vacuum zones on the same container can help. If a zone has vacuum loss, another zone may compensate. Typically, when cups are located on the container’s outer perimeter, the more stable the container will be.

5.6 Piping
The piping (valves, hoses, fittings, filters, manifolds, line layout etc.) should be designed to provide unrestricted vacuum flow. Examples of vacuum plumbing issues are:

- uneven lengths of tubing to different cups can create flow imbalances
- bends and elbows
- fitting sizes
- hose/tubing type and size
- valve type and size

In order to handle unfilled corrugated containers, testing has shown:

Do not use a piping connection or orifice less than 5/16" inside diameter (I.D.) in lines from the vacuum source to the vacuum cup.
Keep the number of elbows (bends) in the piping system to a minimum.

5.7 Vacuum source
Once the above information is gathered, a suitable source can be defined, and should then be attached in such a way as to give the required flow at the cups. Tubing, fittings, valves and filters are all items that can restrict the vacuum flow and reduce the flow at the cups.

5.7.1 Vacuum Generation
Vacuum generation can come from:

(1) venturi type which uses compressed air. individual venturi pumps can be placed at each vacuum cup providing independent vacuum.

(2) vacuum pumps which move high volumes of air at high vacuum pressures and

(3) blowers which move high volumes of air typically at low vacuum pressures.

5.7.2 Vacuum Systems

There are three main types of vacuum systems:

- centralized - larger pump servicing multiple cups.
  - remote mounted and plumbed through tubing to the cups.
  - susceptible to line losses and imbalances in the system.
  - all of the cups are tied together and any leakage at one cup affects the entire system, unless specific valving is used.
  - Lighter weight of the end effector because the pump(s) are remote mounted.
- zoned – multiple smaller pumps each supplying vacuum to multiple cups.
  - allows zones to operate independently.
- decentralized - one pump per cup.
  - typically ejectors (venturi) are used.
  - reliable form of handling, each cup is independent.
  - no line losses to be concerned about, balanced cup performance.
  - quicker evacuation time.
  - heavier end effectors that may be more difficult to install.

6 Summary

The two most important variables that influence the performance of packaging equipment operating with a vacuum apparatus for handling corrugated fiberboard are:

- Volume of airflow at the vacuum cup
- Vacuum cup annular sealing area between the cup and the corrugated fiberboard

The volume of airflow and vacuum cup annular sealing area are generally more important variables than the linerboard porosity and vacuum level ("Hg), as read from the vacuum gauge.

7 Inquiries

Inquiries regarding this document should be directed to:

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APPENDIX A: Apparatus for Measuring Airflow Volume at The Vacuum Cup of an Automatic Packaging Machine

- One air rotameter, capacity 8.3 CFM air— at standard conditions, minimum 1/2" pipe connections. Flowmeters are available from various suppliers such as:
    - Dwyer Instruments, Inc., Michigan City, IN 46361, (800) 872-9141
- One 5" x 5" flat polycarbonate plate, with a hole for 1/2" I.D. threaded connector in center.
- One 20" length flexible tubing to fit 1/2" standard connectors on both ends.

The Plexiglas plate, attached to the flexible hose that is connected to the outlet of the airflow meter, is placed firmly against the vacuum cup on the packaging machine. The float will rise in the rotameter tube to indicate the airflow. The reading on the glass tube corresponds to the air volume flowing through the apparatus. Read the actual air volume in CFM from the air rotameter calibration chart.

Figure 1 Air Flow Measurement Apparatus

When checking the airflow of a packaging machine with multiple vacuum cups, the airflow is measured on one cup while the other cup(s) is (are) open to the atmosphere.

This apparatus is proficient in evaluating actual operating conditions, and in identifying inadequately sized vacuum sources and/or vacuum cups, and excessive airflow loss due to piping arrangement. Most importantly, it is an excellent quality control device to check problems in the vacuum system, such as partially plugged lines and connections due to fiber, dirt, sand, oil, etc.

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