



Packaging — Estimating the filled volume using the flat dimensions —

Part 1: Paper sacks

Emballages — Évaluation du volume de remplissage à partir des dimensions plates — Partie 1: Sacs en papier

At its first meeting in 1975, Sub-committee 2, *Sacks*, of Technical Committee ISO/TC 122, *Packaging*, agreed to create a working group (WG 1) to study methods of relating the flat dimensions of a paper sack to its capacity and if feasible, to make a recommendation for a method. At the very beginning it was pointed out that the volume of a sack is not an exact property, nor is it unique. It is dependent upon the product, the method of filling and any treatment after filling. Nevertheless, a relation between the dimensions and volume was considered to be worth seeking, even if it were to be an arbitrary one.

It became evident very early that establishing the desired relation would be impracticable without a wide range of experiments which were then carried out in France under the direction of the convener of the group. However, difficulties in establishment of the rate of filling and the assessment of the apparent density of the filling material were considerable and so it was impossible to recommend any accurate method.

As the work carried out by the working group was extensive and in any case gave valuable information, the sub-committee decided to publish the work as a Technical Report (type 3). This part of ISO/TR 8281 comprises all the individual results of measurement for paper sacks which can be treated further; for example different kinds of nomograms could be established on the basis of these results.

0 Introduction

This part of ISO/TR 8281 deals with paper sacks. Plastics sacks (of thermoplastic flexible film) will form the subject of ISO/TR 8281/2.

1 Scope and field of application

This part of ISO/TR 8281 establishes empirical equations for relating the flat dimensions of paper sacks to their capacity. The experimental methods used are also described.

2 Reference

ISO 6591/1, *Packaging — Sacks — Description and method of measurement — Part 1: Paper sacks*.¹⁾

1) At present at the stage of draft.

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3 Principle

The general sequence used throughout was

- determination of the mass of the empty sack;
- measurement of the flat dimensions of the sack;
- filling and closure of the sack;
- assessment of the filled sack for degree of filling and, when necessary, addition or removal of contents until the sack was filled with the correct quantity of contents;
- measurement of the filled dimensions of the sack;
- determination of the degree of flexing of the filled sack by measuring the amount of sag when the sack was held up by opposite corners;
- determination of the mass of the filled sack;
- calculation of the volume of the sack, V , by the equation

$$V = \frac{m}{\rho}$$

where

m is the mass of contents (total mass minus tare of sack);

ρ is the bulk density of the contents.

4 Filling material

Polyethylene granules were used throughout as filling material.

The bulk density and granule size varied from occasion to occasion and information on density and size analysis is given in table 1.

Table 1 — Filling materials

Type of sack	Type of filling material	Density kg/l	Particle size analysis (mesh)					
			4 mm	3,15 mm	2,5 mm	2 mm	1,6 mm	1,6 mm
Open mouth pasted valved sewn	Polyethylene cubic granules	0,542	5,7 %	93,5 %	1,35 %	0,1 %		0,1 %
Valved pasted	Polyethylene cubic granules	0,565						
Open mouth sewn	Polyethylene cylindrical granules	0,6	49 %	37,4 %	12,2 %	1,4 %	—	—

5 Test sacks

The test sacks were hand made, either two plies of 100 g/m² paper or three plies of 70 g/m² paper, their dimensions being based on sack sizes in general use and taking into account paper deckles.

6 Procedure

6.1 Filling method

Valve sacks were filled using a small hopper containing a filling spout and means of using compressed air to assist the flow of the granules.

Open mouth sacks were filled manually or by using a small gravity hopper.

NOTE — The assessment of the degree of filling was considered to be most important, as it can be the source of large errors.

The experts in the working group were invited to give opinions and make judgements based on their experience in the field.

In those instances where full agreement was not reached, a further sack of the same dimensions was filled to allow direct comparison and full agreement.

6.2 Closing method

Valve sacks did not require a closure device but self-adhesive tape was used to prevent any spillage of contents.

Open mouth pasted bottom sacks were closed with staples 50 mm from the top.

Open mouth sewn bottom sacks were closed by sewing 15 mm from the top.

With gusseted sacks, the gusset ends were included in the closure in the internal position.

6.3 Measurement of filled dimensions

In the preliminary work a large caliper device was made to measure the dimensions of the filled sacks but it was found easier and more accurate to use a tape measure in conjunction with two large blocks of wood.

7 Expression of results

The symbols used are those of ISO 6591/1.

The sets of results obtained are listed in table 2. The results are listed in the annex.

Table 2 — Number of results

Type of sack	No. of results
Valve pasted	120
Valve sewn	17
Open mouth sewn	120
Open mouth pasted	94

Each set was processed by computer to give a regression analysis, based on the following models:

$$V = b^2 (\alpha a + \beta b + \gamma c)$$

for valve and open mouth pasted bottom sacks, and

$$V = (b + e)^2 [\alpha a + \beta(b + e) + \gamma e + \Delta]$$

where

V is the volume, in litres;

a is the flat length, in millimetres;

b is the flat width, in millimetres;

c is the bottom width, in millimetres;

e is the gusset width, in millimetres;

α, β, γ are regression coefficients;

Δ is a regression constant.

For each type of sack, the following equations were obtained :

- a) volume of sack from the flat dimensions;
- b) filled dimensions from the flat dimensions;
- c) flat dimensions from the filled dimensions.

The results of the regression analysis for the various types of sack are given in 7.1 to 7.4.

The results of the study may also be presented graphically or nomographically.

Some examples of such nomographs are given in figures 1 to 3.

7.1 Open mouth sewn flat and gusseted sack

7.1.1 Volume of sack from the flat dimensions

$$V = (b + e)^2 [0,307\,9\,a - 0,021\,5\,e - 0,150\,8\,(b + e) - 15,9] \times 10^{-6}$$

V is given in litres for a , b , e in millimetres.

7.1.2 Filled dimensions from the flat dimensions

$$A = 0,955\,a - 0,05\,(b + e) - 0,000\,5\,e^2 - 50$$

$$B = 0,82\,(b + e) - 0,000\,35\,e^2$$

$$C = 0,115\,a + 0,128\,(b + e) - 0,000\,25\,e^2 - 5$$

A , B , C are given in millimetres for a , b , e in millimetres.

7.1.3 Flat dimensions from the filled dimensions

$$a = \frac{1}{0,955} (A + 0,05\,B + 0,000\,5\,C^2 + 50)$$

$$b = \frac{1}{0,82} (B + 0,000\,35\,C^2)$$

$$e = \frac{1}{0,000\,25} (0,1\,C - 0,011\,5\,A - 0,012\,8\,B + 0,5)^{1/2}$$

a , b , e are given in millimetres for A , B , C in millimetres.

7.2 Open mouth pasted flat hexagonal sack

7.2.1 Volume of sack from the flat dimensions

$$V = b^2 (0,304\,6\,a + 0,057\,c - 0,148\,b) \times 10^{-6}$$

V is given in litres for a , b , c in millimetres.

7.2.2 Filled dimensions from the flat dimensions

$$A = 0,955\,a - 0,105\,b - 0,000\,5\,e^2 - 10$$

$$B = 0,800\,b - 0,000\,25\,c^2$$

$$C = 0,245\,b + 0,000\,25\,c^2 + 5,9$$

A , B , C are given in millimetres for a , b , c in millimetres.

7.2.3 Flat dimensions from the filled dimensions

$$a = \frac{1}{0,955} (A + 0,105 B + 0,000\,5 C^2 + 10)$$

$$b = \frac{1}{0,800} (B + 0,000\,25 C^2)$$

$$c = \frac{1}{0,000\,25} (0,1 C - 0,024\,5 B - 5,9)^{1/2}$$

a, b, c are given in millimetres for A, B, C in millimetres.

7.3 Valved sewn flat and gusseted sack

7.3.1 Volume of sack from the flat dimensions

$$V = (b + e)^2 [0,235\,5 a + 0,052 e - 0,088\,0 (b + e)] \times 10^{-6}$$

V is given in litres for a, b, e in millimetres.

7.3.2 Filled dimensions from the flat dimensions

$$A = 0,973 a - 0,001\,6 e^2 - 67,6$$

$$B = 0,913 (b + e) - 0,000\,94 e^2 - 28,2$$

$$C = 0,147 (b + e) + 0,000\,86 e^2 + 0,064 a + 10,8$$

A, B, C are given in millimetres for a, b, e in millimetres.

7.3.3 Flat dimensions from the filled dimensions

$$a = \frac{1}{0,973} (A + 0,001\,6 C^2 + 67,6)$$

$$b + e = \frac{1}{0,913} (B + 0,000\,94 C^2 + 28,2)$$

$$e = \frac{1}{0,000\,86} (0,1 C - 0,014\,7 B - 0,006\,4 A - 1,8)^{1/2}$$

a, b, e are given in millimetres for A, B, C in millimetres.

7.4 Valved pasted flat hexagonal ends sack

7.4.1 Volume of sack from the flat dimensions

$$V = b^2 (0,266\,8 a + 0,404\,7 c - 0,139\,9 b) \times 10^{-6}$$

V is given in litres for a, b, c in millimetres.

7.4.2 Filled dimensions from the flat dimensions

$$A = 1,025 a + 1,02 c - 0,002\,8 c^2 - 80$$

$$B = 0,920 b - 0,001\,5 c^2 - 35$$

$$C = 0,095 b + 0,002\,5 c^2 + 58$$

A, B, C are given in millimetres for a, b, c in millimetres.

7.4.3 Flat dimensions from the filled dimensions

$$a = \frac{1}{1,025} (A - 1,02 C + 0,002 8 C^2 + 80)$$

$$b = \frac{1}{0,920} (B + 0,001 5 C^2 + 35)$$

$$c = \frac{1}{0,002 5} (0,1 C - 0,009 5 B - 5,8)^{1/2}$$

a , b , c are given in millimetres for A , B , C in millimetres.

8 Notes on procedure

The information and equations given in this part of ISO/TR 8281 have application in many areas, but users should be aware of limitations and restrictions that can occur. These are summarized in 8.1 to 8.4.

8.1 Influence of type of closing machine

Certain types of sewn closure machine require a definite space above the contents (ullage) to make a satisfactory closure.

Some automatic closing machines will trim away part of the top of the sack before sewing. The equations given may not be satisfactory in these instances.

8.2 Influence of contents

Highly fluidized aerated powders will require sacks of greater volume than given by the equations, in order to let sufficient contents be packed during filling.

8.3 Accuracy

The equations are only accurate to $\pm 5\%$.

The equations are more accurate for sacks of average size.

Application to sacks with dimensions outside the following limits is not recommended:

- width: 350 to 650 mm
- length: 500 to 1 200 mm
- bottom width: 100 to 200 mm

8.4 Other types of sack

Certain types of sack were not included in this study, namely

- open mouth pasted gusseted rectangular bottom sack (SOS);
- open mouth pasted flat turn over bottom sack (pinch bottom);
- valved pasted sewn flat sack with one hexagonal end.

Application of the equations to such sacks may give doubtful results.