## OCCASION

This publication has been made available to the public on the occasion of the 50th anniversary of the United Nations Industrial Development Organisation.

## DISCLAIMER



## FAIR USE POLICY



## CONTACT

Please contact publications@unido.org for further information concerning UNIDO publications.

For more information about UNIDO, please visit us at www.unido.org

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
Vienna International Centre, P.O. Box 300, 1400 Vienna, Austria
Tel: (+43-1) 26026-0 · www.unido.org · unido@unido.org

D03767

Distribution
LIMITED

ID/WG.137/7
18 September 1972

Original: ENGLISH

United Nations Industrial Development Organization

Symposium on the Development of the Plastics Fabrication Industry in Latin America

Bogotá, Colombia, 20 November - 1 December 1972

# FOOD GRADE P.V.C. BOTTLES MANUFACTURING IN FRANCE USE OF BULK P.V.C. 1/

by

Louis Goiran
Rhône Progil
St.Fons France

1/ The views and opinions expressed in this paper are those of the author and do not necessarily reflect the views of the secretariat of UNIDO. This document has been reproduced without formal editing.

id.72-5523

United Nations Industrial Development Organization

Distribution
LIMITED

ID/WG.137/7 SUMMARY
18 September 1972

Original: ENGLISH

Symposium on the Development of the Plastics Fabrication Industry in Latin America

Bogotá, Colombia, 20 November - 1 December 1972

SUMMARY

# FOOD GRADE P.V.C. BOTTLES MANUFACTURING IN FRANCE USE OF BULK P.V.C. 1/

by

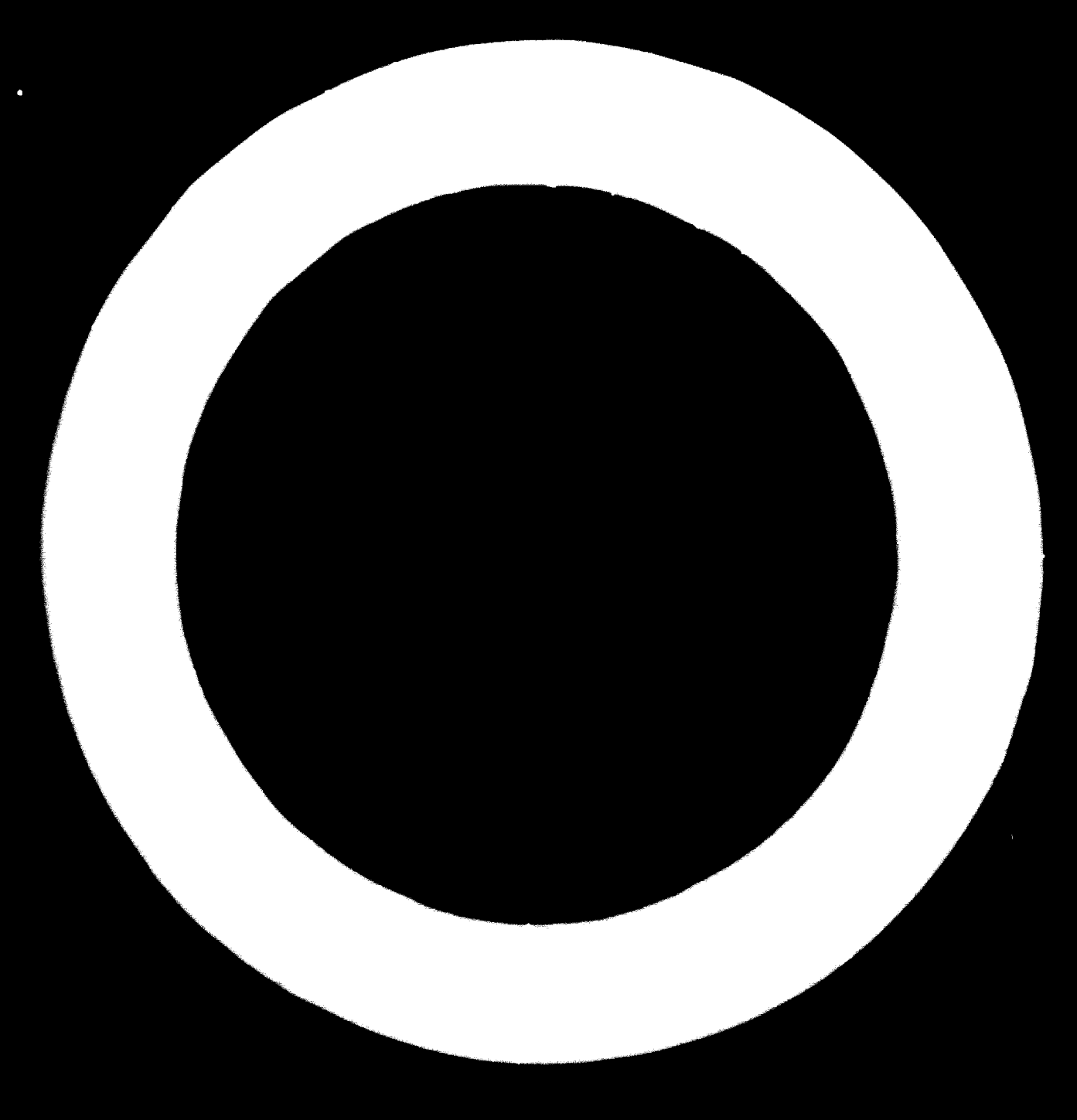
Louis Goiran
Rhône Progil
St. Fons France

An important contribution to the increased usage of P.V.C. in foodstuffs packaging, during recent years, has been its employment in the manufacture of bottles.

This situation has been facilitated by the extrusion blow moulding process which has substantially superceded the original process of high-frequency welding thermo-formed half-bottle shells.

1/ The views and opinions expressed in this paper are those of the author and do not necessarily reflect the views of the secretariat of UNIDO. This document has been reproduced without formal editing.

id.72-5348



Edible oil was the first product to exploit the weight and other advantages of the P.V.C. bottle, a situation favoured by the relatively high market domination of one large producer.

In the bottling of wine P.V.C. has made less impact being utilized only by the supermarkets whose wine sales represent only about 10% of the whole.

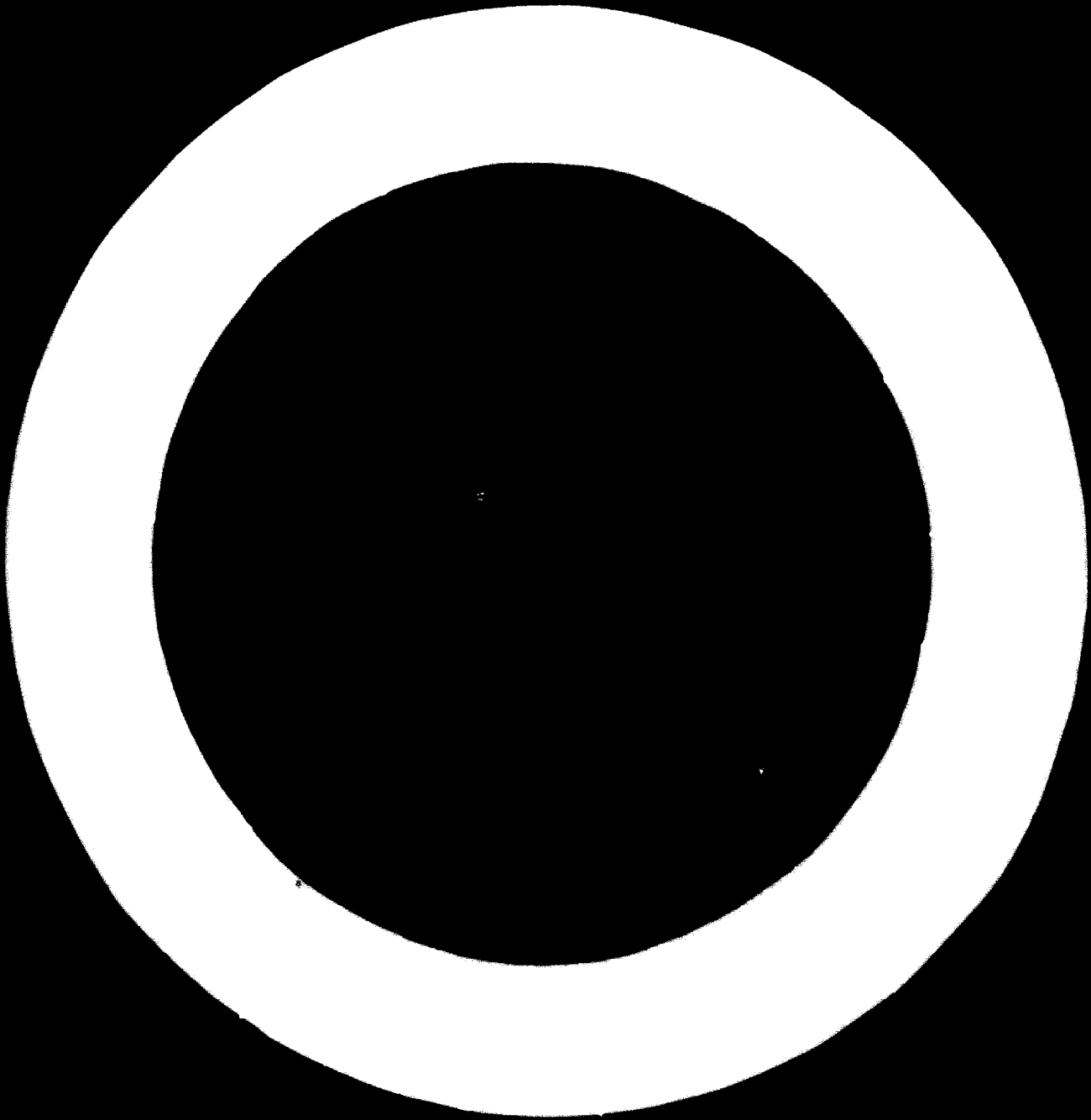
In bottling still mineral waters not only has P.V.C. made a major encroachment on glass but their everyday consumption has also enjoyed rapid growth.

In adapting the extrusion blow moulding process to the manufacture of P.V.C. bottles particular attention had to be paid not only to the critical thermal properties of the unplasticized material with respect to processability but also to the demands from users for diversities in capacities and shapes. Currently the range of extrusion blow moulding machines vary in size from small, single parison, single mould machines to large, double parison, machines embodying up to 14 moulds.

The main advantages of P.V.C. in bottle manufacture include considerable savings in weight and exterior surface area coupled with an attractiveness in appearance which arises from a transparency equal to that of glass and a capacity for accepting pigmentation by a wide range of colours.

Although the selection of the appropriate polymer grade and formulation of the P.V.C. compound is dictated by critical considerations, such as retaining maximum thermal stability during processing while rigorously avoiding ingredients capable of being leached out by the contents, commercial manufacture embodying the re-cycling of 20 - 30% of reground scrap is effected.

The high degree of transparency achieved is met by employing bulk polymerized P.V.C. because of its freedom from emulsifier and protective colloid residues.



CONTENTS


| | | |
|---|---|---|
| 1. | Introduction | p. 3 |
| II. | Historical | p. 3 |
| | 2.1. Renopac Process | p. 3 |
| | 2.2. The blow-moulding process | p. 4 |
| III. | The P.V.C. bottle market in France | p. 4 |
| | 3.1. Case of oil | p. 4 |
| | 3.2. Case of wine | p. 5 |
| | 3.3. Case of mineral water | p. 5 |
| IV. | Transformation equipment | p. 7 |
| V. | Qualities of the P.V.C. bottles | p. 9 |
| | 5.1. Marketing characters | p. 9 |
| | 5.2. Appearance characters | p. 9 |
| | 5.3. Industrial characters of bottle manufacturing | p. 9 |
| | 5.4. Mechanical characters | p. 10 |
| | 5.5. Organoleptic characters | p. 11 |
| VI. | Use of bulk P.V.C. | p. 12 |
| | 6.1. Choosing the P.V.C. | p. 12 |
| | 6.2. Criteria for the choice of P.V.C. | p. 13 |
| | 6.2.1. Answer to industrial manufacturing features | p. 13 |
| | 6.2.2. Answer to other characters | p. 14 |
| | Conclusion | p. 15 |

## I. INTRODUCTION

The use of P.V.C. in the packaging field in France has made extensive headway during the last years.

Among the various transformation techniques, bottle manufacturing for a number of food stuff and other products' packaging has also outstandingly advanced.

This spectacular development of P.V.C. use as packaging raw material is owed to its numerous advantages over its main competitors : glass and polyethylene.

Besides, it must be kept in mind that this advance in P.V.C. bottle packaging occured in France just at the time when mineral water consumption was rising more and more, mainly in great cities.

This accound will allow to give a brief history of the use of P.V.C. for bottling, to note the market trend for this application in France, and to show why Bulk P.V.C. is a choice material by its possibilities in a wide range of formulas, of transformation equipments and of types of packaged liquids.

## II. HISTORICAL

The blow-moulding of hollow shapes is rather a recent transformation technique.

It has advanced in the technological field by the development of more and more improved machines with high output, as well as the formulation field, by the use of thermal stabilisers allowing a P.V.C. transformation similar to that of Polyethylene.

### 2.1. Renopac Process

About 1962, appeared the first P.V.C. bottles with the " Vitroplume " appellation.

These bottles are manufactured by the Renopac Process, consisting in high-frequency welding of two shells of P.V.C. thermoformed sheets.

This process, although the idea was artful, did not last long, for two main reasons :

- The cost price was expensive, owing to the numerous operations required for the obtention of bottles : calendering, vacuum forming, welding.
- Technical problems owed to the quality of weldings : the welding time has to be well adjusted and rather long to obtain good melting of the rigid P.V.C.

The difficulty to obtain perfectly tight bottles has been another reason to let this process aside.

2.2. The blow-moulding process

With the above process, the blow-moulding process was developed and proved the only one to succeed.

This process includes two operations : extrusion and blow-moulding. Extrusion, well known process of P.V.C. transformation, has been developed by the bottles manufacturers, who in many a case, have cooperated with extruding-machines manufacturers to adjust suitable screws, heads and dies.

In any case, only single-screw extruding machines have been used.

There may be some alteration in the blowing-method according to the different constructors, and it is mainly on the bottle formation method in the mould that the patents are based.

Thus the blow-moulding process has advanced since 1962 and allowed the headway of bottle manufacturing for food-stuff packaging (oil, wine, vinegar and at last mineral water, in addition to of course, various pharmaceutical products and cosmetics).

## III. THE P.V.C. BOTTLE MARKET IN FRANCE

The importance of the P.V.C. bottle market in France is owed to the conjunction of several facts favouring its rapid development in the various fields of packaged products.

3.1. Case of oil

France, being a latin country, is an important consumer of edible oil used for food preparation.

Moreover, it is interesting to note that most of the oil is consumed in the south of France.

Until about 1962, oil was delivered in returnable glass bottles ; it was thus necessary for the consumer, either to pay for the container when buying a bottle of oil, or to returnthe bottle . For the oil supplier, he had to send back to the packager perfectly degreased and cleansed bottles, meaning energetic washing and expensive cost price.

With non returnable P.V.C. bottle packaging, there areno ie of these problems.

A main factor of quick development of the use of P.V.C. for oil bottling is the fact that in France, a single oil manufacturer supplies 40 % of the production, the remainder being distributed between only ten others suppliers. These also converted to P.V.C. oil bottling to remain competitive when they saw the main supplier invading the market by efficient advertising.

3.2. Case of wine

For wine, it is the opposite problem. Indeed, although wine P.V.C. bottling only began a few years after oil, about 1964 - 65, its advance was very slow.

Several reasons for this.

The first and main reason is that wine merchants are very numerous in France. There are about 6 000 of them, the most important of which sells only about 15 % of total production, thus most of these merchants are unable to invest in entirely new equipment for wine packaging, and such investment would have but little a chance of increasing their turnover.

The second reason is that, in the case of wine, returnable glass bottles can still match P.V.C. bottles. It is much easier to clean a wine bottle than an oil bottle.

For 1971 :

The cost price of returnable glass plus cleaning is 2 cents for a one liter bottle

The cost price of a P.V.C. bottle is 3 cents " " "

plus often a cardboard box raising the price to 4 cents " " "

thus twice the price of glass packaging.

At the present time in France, the supermarkets have imposed on customers P.V.C. bottle packaging for ordinary wine, simply by refusing to sell and take back glass bottles for ordinary consumption. They thus saved storage space and sales of other goods as well as hands for handling.

Under such conditions, plastic bottles packaging for wine, is only in France about 10 % of total consumption.

3.3. Case of mineral water

France, as surprising as it may seem, is a great consumer of mineral water. Indeed, when this consumption is about 40 liters in France per year and inhabitant, it is only 15 liters in Italy and 10 liters in Germany.

Moreover, most of the consumed water is non gaseous mineral water.

The trench home market is supplied by three important groups who share 95% of total production.

This is the reason for the rapid penetration of P.V.C. bottles in this market.

In november 1968 a mineral water P.V.C. bottle, with 1,5 liter capacity was launched for the first time.

Advertising claimed that this 1,5 liter plastic bottle had the same weight as a 1 liter glass bottle, when they were full.

Since then, penetration had advanced rapidly to the extent of 80% in three years.

## FRENCH MARKET 1971

| Bottled Product | 1971 Potentialities in liters | P.V.C. Bottles penetration rate | Compound products in tons | Percentage of the market |
|---|---|---|---|---|
| Oil | 500,000 | 90 % | 14,000 | 19 |
| Non gaseous water | 2 billions | 80 % | 49,000 | 65 |
| Wine Vinegar | 4 billions | 10 % | 8,000 | 11 |
| pharmaceuticals & miscellaneous | difficult to forecast | | 4,000 | 5 |
| total | | | 75,000 | 100 % |

## TREND and FORECAST of FRENCH MARKET

| | 1968 | 1969 | 1970 | 1971 | 1972 | 1973 |
|---|---|---|---|---|---|---|
| Oil | 11 900 | 13 000 | 14 000 | 14 000 | 14 000 | 15 000 |
| Water | 100 | 12 000 | 32 000 | 49 000 | 55 000 | 60 000 |
| Wine - Vinegar | 3 000 | 4 000 | 6 000 | 8 000 | 15 000 | 29 000 |
| pharmaceuticals and miscellaneous | 3 000 | 3 000 | 3 000 | 4 000 | 6 000 | 6 000 |
| TOTAL | 18 000 | 32 000 | 55 000 | 75 000 | 90 000 | 110 000 |
| Increase for each year over the previous one | | + 78 % | + 72 % | + 36 % | + 20 % | + 18 % |

## IV. TRANSFORMATION EQUIPMENT

The advance in P.V.C. bottle liquid packaging was carried out by means of transformation equipment. This had to be adjusted to the use of P.V.C. as raw material and fulfill the requirements of manufacturers, wishing diversity in capacities and shapes of containers for the sake of attractiveness and ease of customers.

This led to setting-up of a very diversified range of moulds, etc.

This transformation equipment includes an extruding-machine and a blow-moulding device.

The extruding-machine has to be fitted with :

- a screw, allowing gradual processing without thermal shock of the material, with a wide compression area and a compression ratio of from 1.6 to 2.
- a head (either square, or with an elbow) without any acute angle and favouring satisfactory flow of the processed product.

The blow-moulding device is adjusted to the output of the extruding-machine and includes, either one mould, or two moulds in turns, or several moulds fitted on a cylinder.

The blow-forming machines are divided into :

- small machines
- medium size machines
- big machines.

| Type of machine | Small machines | Medium size machines | Big machines |
|---|---|---|---|
| Production Number of bottles per hour | 500 to 1 000 of 1 liter | 1 500 to 2 500 of 1 liter | above 3 000 of 1,5 liter |
| Output in kg/hour | 10 to 35 | 40 to 60 | above 80 |
| **Features of extruding machines** | | | |
| Screw Diameter in mm | 33 to 50 | 60 to 90 | Mill : two screws in L 120 to 130, 90 to 120 |
| Length n.D. | 20 | 20 | 26 and 10/15 and 15/15 |
| Number of parisons | 1 or 2 | 1 or 2 | 1 or 2 |
| **Features of blowing device** | | | |
| Number of moulds | 1 or 2 | 2 to 4 | 6 to 14 |
| Capacity | 0,5 l. to 1 l. | 1 l. to 1,5 l. | 1,5 l. |
| Main types of machines met in France | Bekum S 50/HBD 50<br>ADS PVC (Andouart)<br>Fisher FBH 052<br>Hesta B 335 11<br>Kautex V 8 S 50<br>Moretti | Bekum SE 60/HBD 110<br>Bekum SE 80/HBD 120<br>Fisher FBH 106<br>Kautex S 80<br>Sidel DSL I<br>Sidel DSL II | Sidel DSL III M<br>ADS III<br>Mills type 1301 - 1402 and 1406 |

## V. QUALITIES of P.V.C. BOTTLES

Let us at first try to make out what are the criteria leading to use with advantage P.V.C. bottles instead of glass ones ; thus what are the characteristics required for these bottles.

### 5.1. Marketing characters

First of all, the weight of P.V.C. bottles. A 1 liter bottle weighs about 35 g., whereas a glass bottle of same capacity weighs 600 to 650 g.

This weight factor has effects not only for the consumer who will be rid of the glass overload, but still more at the handling and storage level.

A trial on the spot has shown that large surfaces could be spared for the simple reason that the storage of 1 000 liters requires 60 % less volume with P.V.C. bottles than with glass ones.

Besides, the delivery trucks can carry about 5 000 liters capacity instead of 3 000 glass bottles.

As for medium and long distance transportation, for which the freight cost is function of weight, the advantage of this very light packaging is obvious.

### 5.2. Appearance characters

The P.V.C. bottle is been just as, and sometimes more attractive than the glass bottle by its appearance.

New shapes have been designed, unusual capacities have been studied to make the best of the raw material.

Transparency of the bottles has become just as good as that of glass ones.

Brilliancy of the surface has the attractive appearance of a new thing which will not be used again.

Last, the possibility of manufacturing bottles with various attractive colourings either in the bulk, or by blueing, or by accurate reproduction of the usual colours of bottles, has also led to commercial success.

### 5.3. Industrial characters of bottle manufacturing

For bottle manufacturing to be really industrial, it has to be run in continuous operation during the whole week without any stop for dismounting. This requires well adjusted formulations, provoking no gripping on heads or dies on the long run.

Add to this that the formulas need to have excellent thermal stability allowing them to face a circuit break-down trial which consists in stopping the machine in operation, by simulating a 45 minutes break-down.

An important matter is the behaviour of P.V.C. when blown into the moulds which must never bring along any deposits. Accumulation of these deposits at length choke the blowing devices and harm the surface appearance and brilliancy of the bottle.

The adjusted formula is of outstanding importance.

Indeed, industrial manufacturing of bottles is run with a high percentage (20 to 30 %) of reground product, as, in normal operation, there is, according to the machines used, from 15 to 20 % of compulsory fall, owed to the manufacturing process. The remainder of reground product comes from defective bottles.

5.4. Mechanical characters

The obtained bottles are to undergo quite a lot of very various mechanical stresses which may be enumerated during the following operations.

- Behaviour when filling :
  Mainly in the case of under-vacuum filling, there may be some problems owed to shape, stiffness or weight of the bottles.
- Behaviour while capping :
  Capping machines for glass bottles apply a vertical pressure which the bottle has to face. New and more modern machines, designed for P.V.C. bottles, use lateral compression.
- Behaviour when falling :
  This is an important feature arising at various steps of handling, from the boxing to the use in private houses as well as in transportation. This feature is checked while manufacturing by a quick trial on 50 bottles full of water. According to type of bottle and formulation, a suitable height is chosen for falling, which allows to check possible changes of this feature.
- Behaviour under compression :
  When filled and boxed, bottles are to be transported and stored. During these operations they will undergo stresses owed to the compression of bottles laid over each other, when stacking several pallets.
  In some cases the bottles are assembled into burdens by means of a shrinkable polyethylene film.

These compression behaviour problems bound to the elasticity of the bottle are often solved by appropriate formulations and suitable shapes of bottles.

5.5. Organoleptic characters

The basic quality required from a P.V.C. bottle is to never alter the taste of the food-stuff, as it is intended to be drunk.

The two main organoleptic characters are taste and smell, thus it will finally be the bottling firm who will decide upon the possible taste the packaging may give.

Several tasters will decide about possible alteration of taste or smell of the product packaged in P.V.C. bottles. And this for any food stuff, oil as well as wine or water.

A certain number of trials have been carried out at the bottling firms, in order to accelerate aging of the bottles and thus obtain a quicker answer.

Of course, in any case, glass packaging is taken as a standard, and there lie the secrets of formulas which after all steps of transformation, can match the glass, considered as the most protective packaging for the taste of food stuff.

Specific case of mineral water

In the case of mineral water, in addition to both organoleptic criteria, two other very important ones interfere also :

- Migration into the water of the components of the formula. This migration is checked by a chemical requirement of oxygen test ( D.C.O. ); Oxydation method by a permanganate solution. The rate of oxydizability has to be below 0,3 mg per liter
- Bacteriological development. This development of ordinary bacteria has to be normal, i. e. the bacteria are not to find in the medium a favourable ground for their proliferation.

## VI. USE of BULK P.V.C.

In this chapter we are to show how the specific features of bulk P.V.C. make it a choice resin for bottle manufacturing.

### 6.1. Choosing the P.V.C.

There are at present three main processes for Vinyl Chloride monomer polymerisation to which correspond three types of polymers : suspension, emulsion, and bulk P.V.C.

Emulsion P.V.C., notwithstanding it's remarkable aptitude to processing does not allow, in the present state of knowledge, to obtain perfectly transparent bottles, able to face with success, owing to the presence of an emulsifier, all the organoleptic tests.

Suspension P.V.C., by far the most world-wide used for rigid P.V.C. extrusion, stands as granules of diameter between 80 and 150 microns. Including but little operation residues (particularily colloïd) it can give quite satisfactory bottles.

The less known, but the purest is the bulk-polymerised P.V.C. Besides the residues of initiator it contains no other foreign matter.

As a result of the complete absence of emulsifier and of protecting colloïd :

- transparency is uneaqualed in any other polymerisation method,
- neutral resin P H,
- good thermal stability,
- low water absorbtion.

CHARACTERISTICS of the RESINS

| Measured Characteristics \ Type of resin K W 57 | Bulk resin | Suspension resin |
|---|---|---|
| Apparent density g/cub. cm | 0,62 | 0,53 |
| Outflow time of the resin in sec. | 20 | 25 |
| Porosity g. DOP p.c.r. | 11 | 8 |
| Saturation rate p.c.r. | 115 | 95 |
| Plasticiser absorbtion time p.c.r./min. | 8 | 6 |
| Processing time Brabender min. | | |
| T° 170°C | 1,5 | 2,5 |
| T° 200°C | 0,5 | 1,5 |

## 6.2. Criteria for the choice of P.V.C.

Several basic criteria are the guide lines for the choice of a P.V.C. intended for bottle extrusion. They are bound to the qualities required from the final item.

It will be seen that bulk P.V.C., by its general qualities, is able to answer perfectly the requirements of such a difficult market as that of foodstuff packaging bottles.

### 6.2.1. Answer to industrial manufacturing features

A resin, answering the industrial manufacturing features, has to be very versatile, making the best of all kind of changes which occur in a workshop and fit for as many kinds of machines as possible.

If the characteristics of bulk P.V.C. and suspension P.V.C. of same molecular weight are compared, the difference of apparent density between these two types of resins is striking.

This factor is to play an important part when using the resin in the various steps of transformation.

With bulk P.V.C. it will be possible to load the high-speed mixer about 15 % more, thus allowing greater production capacity.

Besides, this high apparent density and the good flowing ability of the powder will be important factors to obtain good filling of the screw flight in the extruding machine and thus satisfactory output.

These two facts bound to the very special morphology of Bulk P.V.C. win the appraisal of transformers.

Another basic character of bulk P.V.C. lies in its quick and homogeneous processing allowing the use of any type of equipment.

Homogeneous processing also allows to operate the stuff without local overheating and thus without gripping or decomposition hazards.

It is very difficult to compare statically the thermal stabilities of two P.V.C., the informations obtained are often illusive and do not correspond to the results with the equipment.

In fact, processing obtained by heat contribution to the stuff by means of two kinds of energy, thermal and mechanical, is a frail equilibrium. If too much energy is wasted as heat, then appears overheating of the stuff, and very often difficulties for extrusion and blowing.

Bulk P.V.C. allows to avoid such uncontrolled self-overheatings thanks to its easy and quick melting, and keeps clear from difficulties borned to lack of thermal stability.

6.2.2. Answer to other characters

In the field of P.V.C. use for food-stuff packaging, the purity of the resin plays an important part. In fact, for a bottle compound formula to be accepted, it has to face a certain number of trials, particularly organoleptic and migration tests.

The more the P.V.C. will be free from foreign matters and the simpler will be the compound's formula, the best will be the results of the various tests.

Bulk P.V.C. is perfectly suitable and meets this requirement, it only contains the remainder of the polymerisation initiators.

Contrarily to other resins, it contains no other auxiliary agents (colloïds, buffing agents, etc...).

Besides, its satisfactory processing may allow, in some case, the use of adjusted formulas including less products capable of migrating into the liquids contained in the bottles.

From an appearance point of view, Bulk P.V.C. after transformation, leads to bottles with a very smooth and brilliant surface, free from " fish-eyes ", highly appreciated by transformers.

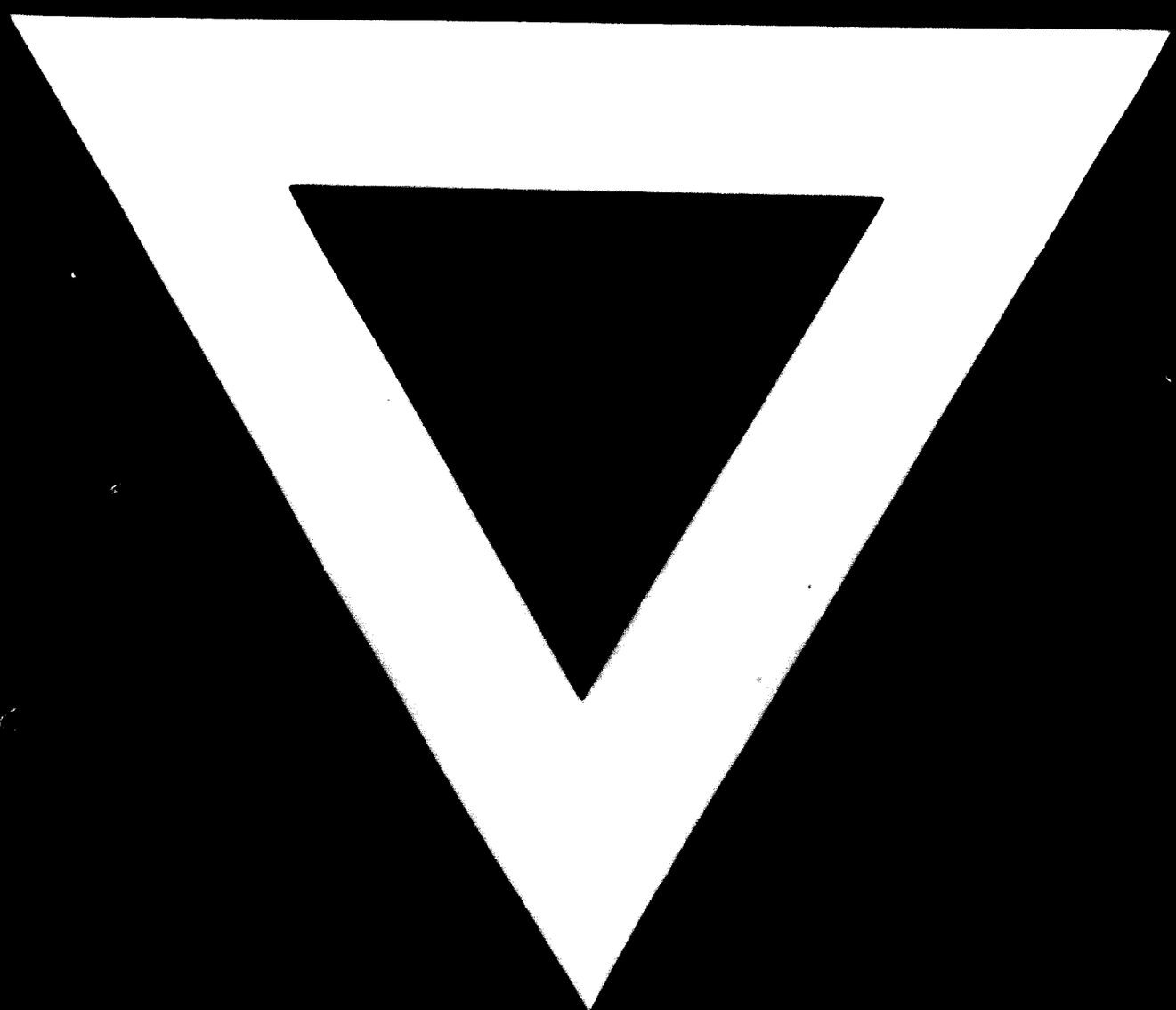
## CONCLUSION

The P.V.C. bottle market for food-stuff packaging has had an outstanding development in France thanks to a very favourable ground.

The use of bulk P.V.C. has also contributed to this advance owing to the particular qualities of the product.

Many a country has understood the advantage of using bulk P.V.C. for this application which from its present embryonary state is bound to expansion in the years to come.

-:-:-:-:-:-:-



# 10.7.74