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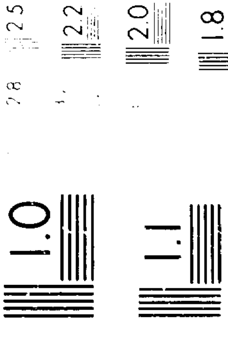

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12 May 1983
English

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CONSOLIDATION OF THE MEXICAN INSTITUTE
FOR ASSISTANCE TO THE INDUSTRY

DP/MEX/82/010

MEXICO

Technical report:* Packaging laboratories (glass packaging)

Prepared for the Government of Mexico
by the United Nations Industrial Development Organization,
acting as executing agency for the United Nations Development Programme

Based on the work of Henk de Waal,
Consultant in packaging laboratories (glass packaging)

United Nations Industrial Development Organization
Vienna

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CONTENTS

SUMMARY

This mission was meant as a first introduction of LANFI with the manufacturing and testing of glass containers, to decide what activities LANFI should execute in this field in the interest of industry, government and consumers and what should - be done to make this possible.

Visits were made to glass container factories and several bottling plants, including food, beer, wine and pharmaceutical - factories.

It was found that, although glass factories appear to be well equipped, breakage figures on filling lines are higher than necessary, that quality control of the incoming ware is still in its infancy at most bottling plants and that problems are due to grow, since filling line speeds are not yet up to international standards in most cases.
With the results of the factory visits the most urgent activities of LANFI on glass containers were selected. They include quality control of containers, with emphasis on strength and other aspects that also involve consumer protection.

A brief survey was made of the existing national standards on glass containers and some standardization meetings were attended. It was found that the influence of the glass industry at these meetings is rather high, which is reflected in

some of the figures in quality specifications,included in - the standards. There is a need for knowledge on glass conta iner manufacture and properties outside the glass industry in Mexico.

The fact that the glass industry in Mexico is practically a mono poly industry certainly has something to do with this and it only makes LANFI activities in this field more valuable.

Further activities during the mission included a 5-days train ing course presented by the expert at LANFI on glass con- tainer manufacturing, properties and testing. Also, the --- expert participated in a 2-days seminar concerning glass con tainers, organized at LANFI.

A detailed list was prepared as a proposal for the equipment to be installed for testing of glass containers, including - possible suppliers and price estimates.

Proposals for practical and theoretical training courses abroad for LANFI-personnel have been made and included in the report.

Suggestions have been made for future LANFI projects on glass containers and for incorporation of glass packaging in food - processing projects.

The continuation of UNIDO - support to LANFI in the field of glass packaging is highly recommended. It should not only --

include further assistance to start up the planned activities but in future also expert help for special topics like chemical analysis and extraction of poisonous elements from coloured glass tableware and glazed enamelled products likely to have contact with food.

1. INTRODUCTION

1.1 Project Background

In 1972 the agreement basis between the Mexican Government, the United Nations Development Program (UNDP) and de United Nations Industrial Development Organization (UNIDO) were stablished, to create a Mexican Packaging Institute (Instituto Mexicano del Envase y Embalaje- IMEE) organism dedicated to the study, information, training, technical assistance, research and programming of the - packaging development in Mexico.

In April 1977 the IMEE was suceeded and integrated by the Mexican Institute for Assistance to the Industry (Instituto Mexicano de Asistencia a la Industria - IMAI).

For technical and economical reasons all the activities - of the Institute as well as programs and immediate plans were related and developed exclusively in the packaging - area. On July 1st, 1979 the project started again as - "Consolidation of the Mexican Institute for Assistance to Industry" DP/MEX/78 /011.

In April 1981 the IMAI and its personnel, equipment and budget were integrated to the National Laboratories for Industrial Development (Laboratorios Nacionales de Fomen to Industrial- LANFI) due to the industrial development policies and a result of the Administrative Amendment, reform that is looking for a more efficient public sector. LANFI is a public decentralized organism dedicated to research and development as well as to provide assistance to the industry in the areas of packaging, food and chemical products.

Because of the Mexican Government needs and the LANFI structure, the IMAI Consolidation Project will continue with mayor extent, concentrating its activities in two main areas, food processing and packaging. The new project is called: "MEX/82/010 Research and Development of Processed and Packaged Food Technology"

Generally the purpose fo this project is to collaborate with the Mexican Government Programs by participating with technical support in the areas of food and packaging process and technology. Some of the objectives of this project are: to develop the maximum advantages of food resources, to make process criterion homogenious, to diffusse the use of packaging technology, to participate elaborating new standards and the industrial training in the areas of food and packaging.

The project is supervised by a project manager, appointed by UNIDO, Mr. Luis Fernando C. Madi. Unfortunately Mr. Madi was not present during the stay of the expert at LANFI.

1.2 Objectives of the Mission.

The original job description, requiring an expert on -- glass packaging, was accepted without changes and includ ed the following activities:

1. Prepare a study on the essential tests to be performed by the Laboratory of LANFI, according to its function of ap plied research, quality control of packages and packaging materials and to give technical assistance to the -- industry.

2. Make an appraisal of raw materials, techniques and equip ment used in the country for the manufacture of glass -- packages, both from the technological and economic points of view.

3. Visit the food and packaging industries and related organizations in Mexico for orientation of the LANFI´s programs related to the glass area.

4. Train counterparts in packaging and packaging materials - testing (glass area) according to the needs of the Mexican industry.

2. Description of work performed and findings

2.1 Introduction

The present mission was the first in the field of glass packaging, since it is a new field LANFI might enter. For that reason, much emphasis was placed upon visits - to industry, to obtain information on the needs and pro blems of mexican industry concerning glass packaging.

With the information obtained from those visits, a gene- ral set up could be made for the tests to be performed - by LANFI on glass containers in the future and the equip ment and training required for its realization.

Also, a training course was given at LANFI, covering -- briefly all main aspects of glass container manufacture, properties, design, quality control and other tests.

Those, and further activities are described in more detail below.

2.2 Visits to glass industry

Around 80% of the glass industry is in the hands of one - company, the "Grupo Vitro", with over 50 plants, 5 of them devoted to the manufacture of glass containers.

A general review of the glass industry in Mexico was - included in the Pira-report 80/III DR of April 1981. A copy of the pages in this report, related to glass, is included in this report as Annex I.

Three of the factories, belonging to the Vitro group were visited, two in Queretaro and one in Mexico,D.F.. Details of those visits are given in Annex II.

The general impression, those plants make is good, Vidriera Queretaro was opened only in 1979 and is equipped with the most modern forming machines available. Know how -- seems to come mainly from Owens Illinois, USA, as is the case in many countries. Raw materials are obtained locally, often exploited by the company itself. Sand, for instance, comes from Veracruz mainly, and the Vitro group -- owns the production plant. This makes the group quite -- self supporting.

Quality control is up to date as far as equipment is concerned. All the necessary equipment for testing is available, including some in-line inspection apparatus, al-- though not yet on all lines.

It is clear, that the Vitro group is in principle able to - produce good quality ware. Whether this always happens is another question. The fact that the customers hardly have a choice (the main "competitor" , FANAL, has the same owner as one of the main beer companies and produces almost exclusively for this factory), is an important point in this respect.

The company admitted that the internationally owned customers usually get better quality than others, who were less powerful and did not have input quality control facilities. It seems that here could be an important task for LANFI.

Visits were also made to two smaller glass factories. -- (See annex II).

It appears that those factories are in great need for -- technological assistance, especially on the production of coloured and opal glass (For cosmetic glass, for instance). In spite of the importance to give assistance to the small scale industry in Mexico, it does not seem to be a task - for LANFI to include this in the work program. A university program seems more appropiate.

2.3 Visits to bottling plants.

Five bottling companies were visited, including food, - wine, beer and pharmaceutical companies.
Details are given in Annex II.

In general, glass container handling is not completely - automatic and filling line speeds are not extremely high (except in the beer factory). In many plants, however, more modern filling lines are being designed right now.

In most cases, as a first reaction to questions about the quality of glass containers, it was said that no special problems existed. However, further inquirements and personal observation showed that , although filling speeds - are generally lower than in Europe, breakage figures - are higher (around 1%).

Since input quality control is limited to visual defects and capacity in most plants, the reasons for this cannot be specified exactly,but there are indications that glass quality is one of them. For instance, in one factory, - where input quality control did include dimensions and some strength aspects, a batch rejection figure was mentioned of around 15% .

This sounds very serious indeed, but it could not be verified in any other plant. However, in the beer factory, - where filling line speeds are more or less up to the international standards, and input quality control has not yet been organized; breakage figures for non-returnable bottles went up to 5%.

When discussing the importance of quality control of - the incoming containers, most bottling plants reacted that the value of such tests was limited, since there was really no possibility to change to another supplier. It was generally agreed that testing against national - standards by LANFI could be a first step to improve the situation.

2.4 Standardization

Standardization of glass containers is quite far in Mexico. A list of existing and drafted standards is given in Annex III.

The standards are based mostly on existing international standards and the result is in most cases quite acceptable.

In a standardization meeting on containers for alcoholic drinks, some decisions were actually based on laboratory tests, recently performed at LANFI. We consider this to be an excellent initiative.

There is one point we want to mention here, since it has reference to possible future LANFI programs on glass containers. There is a tendency to include in the standards rather high acceptable quality levels for defects that -

could create danger to the consumer and also rather low levels for strength. Possibly this is due to the large influence of the glass company at those meetings, - since it is only the glass factories that possess the necessary knowledge to make technical remarks. Also, the specifications for internal pressure resistance for pressurized alcoholic drinks are lower than usual in most countries. This could lead to explosions and thus create danger for the consumers. This shows the necessity to - train people at LANFI in the field of glass containers.

2.5 Lectures and Training.

A training course of 5 days was organized at LANFI, covering the following subjects:

- Composition of glass and raw materials.
- Manufacturing of glass containers.
- Physical and chemical properties of glass.
- Technical design aspects of glass containers.
- Physical and chemical testing and quality control of glass containers.

A list of LANFI personnel attending this course, is given in annex IV. This list also includes other couterparts - at LANFI.

One of the problems we had to face during the mission, was the fact that a glass group has not yet been formally organized at LANFI. This means, that the possibility exists -

that new or other personnel will eventually be added - to the group, attending the course. For that reason - it was decided to attach the full text of this course to this report as an Annex (Annex V) and to leave copies of the slides used.

Two papers were presented at LANFI for all personnel, - one on glass manufacturing and one on design and properties of glass containers.

On August 5 and 6 a seminar was organized at LANFI on - glass containers, called "Envases de Vidrio en Mexico". The program of this seminar is given in Annex VI.

The author presented 3 papers at this seminar, one on technical aspects of design of glass containers (included as Annex VII), one on properties of glass containers (Annex VIII) and one on quality control, legislation and standardization of glass containers in the Netherlands - (Annex IX).

Prof. Mannheim, another UNIDO-expert at LANFI, presented a paper on preservation of food products in glass. There were also papers by industry representatives, as indicated in Annex VI.

Besides LANFI-personnel, there were 31 participants attending the seminar, from government, industry and universities, which reflects the great interest in the subject.

2.6 Conclusions.

Our experiences indicate that there is a need for LANFI-activities on glass.

Technical assistance to the food and packaging industry could be provided by specializing on quality control and testing of glass containers.

It is to be expected that in the near future new filling lines will be installed in many bottling plants. Following the trend in other countries, those lines will require better glass quality (strength and dimensions) because of more automation and higher speed. Since already now - the breakage figures are relatively high, problems are - due to appear. LANFI should anticipate to this situation by checking the quality of containers against national -- standards. Also, LANFI know-how on glass could be used - in technical discussions between the glass suppliers and their customers and in the preparation of standards to reduce the influence of the glass suppliers in those discussions.

In a later stage LANFI could provide further assistance, also to glass manufacturers, by performing technical design studies, relation between strength, glass weight - and design, etc.

LANFI activities on glass could also be important in the field of consumer protection. As described before, there is a tendency to underestimate this aspect by accepting relatively high AQL-levels for critical defects and low internal pressure resistance requirements for some pressurized liquids. LANFI could perform experiments to show the consequences of this. These experiments should include abrasion tests, bursting pressure tests, etc. In a later stage a detailed program has to be defined. First the necessary equipment has to be obtained and installed and the personnel has to receive adequate training.

We have prepared a list of equipment for glass testing as complete and detailed as possible at the moment. It has been included as annex X to this report. It contains a description of the equipment, the tests for which it is required (with reference to ASTM- tests where appropriate) possible suppliers and a price estimate. A subdivision has been made in three groups. The first two groups are required for quality control of physical properties. It contains all the standard equipment that should be available in a laboratory for quality control of glass containers. Group A includes the most urgent, group B the slightly less urgent apparatus. The third group is required for physical and chemical testing of glass properties.

The total price estimates for the three groups amount - to US $ 52,000.00 - US $40,000.00, and US $[illegible]2,500.00 respectively, excluding transport costs, etc.

Apart from ordering and installing equipment it will also be necessary to give LANFI personnel of the packaging -- department appointed to work on glass packages a more intensive training than the expert has been able to give - during his stay.

A list of books, to provide background information on glass and glass packaging is given in Annex XI.

It is very essential to send al least two people abroad - for theoretical and practical training.

Good basic training on glass is provided by the Glass -- Department of the University of Sheffield, United Kingdom. There is a short three months´ course, starting each year in october (always overbooked; subscriptions have to be made in june the latest). The complete course, however, -- takes 9 months, from october till june. Details are given in Annex XII.

Two very specialized short courses on glass containers -- (3 1/2 days each) are provided by American Glass Reseach, Butler, Pa., USA. Details are also included in Annex XII.

Practical training could be provided by the expert in his department on quality control and testing of glass containers at TNO in the Netherlands. A two month -- course could be organized.. It could include factory - visits, sampling, testing, etc.

A training period in the Netherlands could also be used to make a start with a LANFI-project on recycling of -- glass containers. Much work has been done in this field in the Netherlands and the trainees could study methods, results etc, of this activity, to use as a basis for a - similar study later in cooperation with the mexican govern ment.

Another suggestion we would like to make, is to include glass packaging more in food processing studies at LANFI. For certain products, like fruits and vegetables (chiles, peaches, tomatoes) a comparative study could be made --- between packaging in cans, in plastic and in glass on -- shelf life, filling line handling, migration, sealing, - light effects, etc. The results of such studies could be valuable for the food industry and it could give LANFI the opportunity to become more acquainted with glass packaging. Jars with twist off closures could be used, since those - can be closed by hand. However, the purchase of a manually operated crown cork closing machine seems indispensable.

3. RECOMMENDATIONS

1. LANFI has a very extensive packaging department, covering practically all packaging materials except glass.

   Since in Mexico glass is one of the most important packa ging materials in use to day, with a yearly consumption of 7,000 million units, it is strongly recommended to -- complete the packaging department with a section on glass containers.

   In fact, the conclusions of the present mission, as presen ted in section 2.6 of this report, indicate that LANFI - should start activities on quality control and testing of glass containers as soon as possible, in the interest of government, industry and consumers.

2. At first, activities should mainly be directed to the - government (consumer protection, recycling studies) and the bottling industry (checking quality against standards and specifications). In a later stage design-strength -- studies etc., could be done for glass manufacturers.

3. As a start, books and equipment, described in detail in Annex X and XI, should be ordered.

   Preferably, the equipment included in group A and B should be ordered simultaneously;group A, however, is absolutely needed to perform the most essential tests.

The equipment included in group C, would be needed in case LANFI decided to test chemical properties of containers and physical properties of the glass material.

4. A training period abroad is needed for al least two - members of LANFI personnel, assigned to work on glass containers.

Theoretical training can be obtained in a 3 or 9 month - course at the University of Sheffield, later to be completed with short courses at AGR (see annex XII for details).

Practical training could be provided by the glass department of the Institute of Applied Physics TNO in Delft, the Netherlands. A 2 or 3 months course could be organized including factory visits, sampling techniques, - testing and quality control and possibly a short project on recycling of glass containers, to be continued later in Mexico.

5. Glass packaging should be incorporated to a larger extend in LANFI activities in food processing. Comparative studies could be made between packing of fruits and vegetable products (e.g. chiles, peaches, tomatoes) in cans, -

glass and plastic. Glass could also be used as a reference in the study of metal contamination from cans.

6. LANFI-activities on glass should include studies on extraction of poisonous elements from tableware, made from coloured glass, enameled metal and glazed ceramic.

7. LANFI should use every opportunity to strengthen ties with industry. Personal contacts and visits to discuss possible LANFI assistance are essential.

It should always be made clear that LANFI-activities are meant to provide technical help to industry. Too often institutes like LANFI are considered by industry as some kind of government control office . Everything should be done to avoid that. When checking quality against national standards, for instance, this should be done in cooperation with and after aproval of the bottling company concerned.

ANNEX I

DATA ON THE GLASS CONTAINER INDUSTRY IN MEXICO

1. STATISTICAL SOURCES

Most of the statistics in this section are based on those available from the Direccion General de Estadistica, Secretaria de Programacion y Presupuesto (General Statistics Bureau, Programming and Budget Secretariat). Trade data were obtained from the Instituto Mexicano de Comercio Exterior - IMCE (the Mexican Institute for External Trade). Further statistics were collected from a sample of glass manufacturing companies and where these have been used they are described as "trade estimates".

2. TOTAL NATIONAL CAPACITY

Estimated total national capacity of glass containers in 1970 is estimated to have been in the region of 1.6 thousand million units per year, which has increased to 4.2 thousand million units per year currently, an increase of 162.5% over the period, averaging 13.5% per annum. If current investment plans are realised, capacity will increase to approximately 8.0 thousand million units per year by 1985, a slightly slower average increase of 10.5% per year. This should be adequate to meet anticipated growth in consumption of glass packaging. 1979 was a year of considerable expansion for the glass industry as a whole, but some ambitious expansion plans were delayed by problems in construction of plants. However, a more promising development was the opening of the Vidriera Queretaro plant by the Grupo Vitro. Currently this facility is only working at 50% capacity so production expansion is possible in this area.

Currently, the industry overall is working 90-100% capacity mostly to meet domestic demand.

3. INDUSTRY STRUCTURE

The glass industry as a whole is very concentrated in Mexico and the same is true of the glass packaging sector. Grupo Vitro, dominates the industry with 80% of the total. This group comprises Vidriera Monterrey, Vidriera Mexico, Vidriera los Reyes, Vidriera Guadalajara, and Vidriera Queretaro amongst others, as well as the specialist ampoule manufacturer Envases de Borosilicata.

Of the 51 plants in the Vitro Group, nine are devoted to the manufacture of glass bottles; in 1978 they produced 2.33 thousand million units and in 1979 an estimated 2.80 thousand million - an increase of 20%.

The remainder of total industry is comprised of small companies, eg Panamerica de Vidrio (specialises in cosmetics sector), Vidriera Oriental and Nueva Fabrica Nacional de Vidrio (FANAL), none of which has a significant share of the glass packaging industry. This high level of concentration is not likely to change during the forecast period.

The industry is estimated currently to be 50% in Mexico DF but it is expected that further expansion will be in other areas and thus the relative importance of the DF will be reduced. This trend to decentralisation will include both manufacturing plants and administrative facilities.

TABLE 2.46 MEXICAN PRODUCTION OF GLASS CONTAINERS 1975-1979

000 units

	1975	1976	1977	1978	1979
Bottles	2,492,531	2,543,648	2,915,155	3,170,086	3,496,598
Jars	172,501	169,778	155,494	192,679	171,135
Ampoules	214,232	270,243	272,993	265,388	268,971

Source: Direccion General de Estadistica: Secretaria de Programacion y Presupuesto

The production in the different sections of the glass container industry has varied greatly for the period under review. Bottle manufacturers have recovered well from the recession of 1975/76 and in 1978/79 gained an increase of 10% in the volume of production. Glass jars - mainly for the food and pharmaceuticals industry - have been less fortunate, and except for 1977/78 when output rose by 24%, the trend has been to lower levels of production with a fall of 11% in output between 1978/79. This must reflect the lower levels of demand in consuming industries markets as a result of de-stocking, and the substitution by plastics packs, especially for pharmaceuticals. In the case of ampoules, after a spectacular jump of 26% in 1975/76, improvement has been modest with a 1.4% increase in output for 1978/79.

The remainder of this section concentrates solely on glass bottles, as these represent the bulk of glass packaging (see table above) and data was not available currently on other forms of glass packaging.

5. TRADE BALANCE

The volume and value of imports of glass packaging products vary considerably from year to year since they are used mainly to top up domestic production to meet the demand. The table below shows data for recent years.

TABLE 2.47 IMPORTS OF GLASS BOTTLES 1975-1980 BY VOLUME AND VALUE

volume in tonnes

	1975	1976	1977	1978	1979	1980*
Bottles up to 5 litres	413.2	435.9	110.0	na	258.7	353.2
Bottles of 5 litres and over	40.5	21.8	10.8	na	1.6	38.5

	value in 000 pesos					
	1975	1976	1977	1978	1979	1980
Bottles up to 5 litres	2661.6	1965.2	2204.1	na	3147.8	9750.1
Bottles of 5 litres and over	116.7	96.0	106.7	na	25.1	232.0

* estimated

Source: IMCE (Instituto Mexicano de Comercio Exterior)

These import figures show the effects of the economic crisis of 1975/76. When demand for glass packaging fell, users and producers were left with considerable stocks which had to be used. This de-stocking was still continuing into 1977 and caused a considerable reduction in imports. Since then the industry has been expanding but apparently not fast enough to meet domestic demand, and as a result imports have started to increase again to top-up domestic supply.

TABLE 2.48 EXPORTS OF GLASS BOTTLES 1975-1980 BY VOLUME AND VALUE

	Volume (tonnes)	Value (000 pesos)
1975	22.8	55.2
1976	32.3	107.0
1977	78.6	408.2
1978	na	na
1979	16.1	79.8
1980	13.5	125.3

Source: IMCE

Exports, as the above table shows, are also at a relatively low level, with no manufacturer having more than 5% of production destined for export. Most of this export of glass packaging is to other countries in Central and South America.

As far as the glass industry itself is concerned, there is little import of raw materials other than special ingredients, eg selenium, sodium dichromate, sodium carbonate and other cobalt colourants. Some silica and sand, up to 10% of requirements in some cases is also imported.

6. MARKET SIZE

The consumption pattern for glass bottles is shown in the table below.

TABLE 2.40 CONSUMPTION OF GLASS BOTTLES 1970-1985

million bottles

1970	1975	1980	1985
1,666.7	4,045.0	6,382.5	7,756.6

Source: Estimates

These consumption figures suggest that at least for the next five years, glass packaging production in Mexico should be adequate to meet the growth in domestic demand, provided the planned new capacity does come on-stream.

The annual percentage increase declines throughout the period in the face of competition from plastics bottles and metal cans for beer and carbonated beverages.

7. END USES

The end-market breakdown for glass containers varies from one manufacturer to another, but for the industry as a whole the breakdown of end-use is estimated to be as shown below.

Beer and alcoholic drinks	28%
Carbonated beverages	37%
Food	25%
Cosmetics and pharmaceuticals	13%
Other	2%

Source: Trade estimate

It is possible to identify a number of potential threats to the glass packaging industry. Firstly, there is the possibility of legislation on non-returnable bottles. From discussions with both manufacturers and users, a move of this sort is considered to be unlikely, but such a legislative change would have a considerable effect on the industry. As an additional problem, there is substitution potential to either cans for beer and carbonated beverages and to plastics in food and cosmetics/pharmaceuticals markets. In particular milk is now being increasingly packaged in waxed board cartons, and cooking oils and shampoos tend now to be in plastics bottles. If plastics packaging in particular is developed to give improved product presentation and better impact strength, then this will certainly increase the rate of substitution of plastics for glass. In the cans versus bottles area, the main threat to glass must be in the area of two-piece cans of either tinplate or aluminium. As new capacity is installed these packaging products will become more competitive with glass. Glass jars on the other hand seem to be in a fairly stable position and this market is expected to grow at approximately 8-10% per annum to 1985.

8. PRICE TRENDS

The prices of individual glass packaging products have varied in the last 10 years, but for the glass packaging industry as a whole the table below shows the trend in prices.

TABLE 2.50 PRICE INDEX FOR GLASS PACKAGING PRODUCTS 1970-1980

1970 = 100

1975	1980
140	225

Source: Industry estimates

With the increases in capacity which are either in progress or planned and the ready availability of raw materials, prices of glass packaging products are likely to remain fairly stable, in line with the level of inflation in the economy as a whole. The influence of the Government price controls and the differing experience of the producers and consumers of glass packaging have not been studied in great depth, but given the structure of the industry some form of price regulation would appear to be necessary.

9. TECHNOLOGICAL DEVELOPMENTS

Most glass container developments in recent years have been in beverage bottles amongst which are: non-returnable bottles, lighter-weight bottles, plastic-coated bottles, and bottles with a plastics shield. Non-returnable bottles for beers and carbonated beverages are becoming more common. The latter three developments are basically the same technology, ie the use of shrink and shrink foamed plastic coatings. For the most part, plastics coatings are only being used for carbonated beverages since the pasteurisation of beer would be more difficult with a coated bottle. The advantages of these packs are that they are lighter weight, they eliminate the need for in-plant labelling and they give better print and graphics quality. These innovations when applied in other countries, notably the USA, have reduced the total packaging cost and enabled glass bottles to offset in some degree the traditional cost advantage of the metal can over the non-returnable glass bottle. At present the situation in Mexico has not reached a point where these nicer advantages need to be thought about. However, if for example energy costs, particularly electricity, escalate, then some of these innovations would help glass retain its competitive position.

ANNEX II

LISTS OF VISITS TO INDUSTRY AND PERSONS CONTACTED

June 18

Laboratorios Merck
Q.F.B. Jorge León González

June 25

Vidriera México
Ing. Wigbert Villafuerte

June 30

Vidrio Artístico Feder's
Sr. Felipe Dertlingher

July 2

Vidriera Querétaro
Ing. Carlos De Mucha I.

July 2

Envases de Borosilicato, S.A.
Ing. José Luis Gutierrez B.

July 16

Compañía Pedro Domecq
Sr. Salvador Trejo

July 19

Compañía Herdez, S.A.
División Mc. Cormick
Q.F.B. Alfredo Acuña

July 26

Cavas Bach
Ing. Juan Cordero

July 29

Maquiladora y Decoradora de Envases, S.A.
Ing. Bernardo Rodríguez

July 30

Cervecería Modelo
Ing. C. Ramírez

ANNEX III

MEXICAN OFFICIAL GLASS STANDARDS

NOM-EE-12-1974	Envases de vidrio para productos medicinales de uso oral ó tópico
NOM-EE-13-1975	Ampolletas y frascos, ámpula de vidrio para uso medicinal, elaborados con tubo de vidrio borosilicato
NOM-EE-24-1976	Envases de vidrio para leche y crema
NOM-EE-25-1976	Envases de vidrio para aguas envasadas con o sin gas
NOM-EE-26-1968	Envases de vidrio para aceites comestibles
NOM-EE-27-1968	Envases de vidrio para cerveza
NOM-EE-29-1979	Envases de vidrio para productos de perfumería y cosmética
NOM-EE-30-1977	Envases de vidrio para alimentos en general
NOM-EE-31-1977	Envases de vidrio para alimentos infantiles
NOM-EE-32-1977	Envases de vidrio para bebidas alcoholicas en general
NOM-EE-33-1978	Envases de vidrio moldeado para productos medicinales
NOM-EE-34-1978	Envases de vidrio para productos industriales en general
NOM-EE-80-1980	Envases . Vidrio. Pruebas de presión interna
NOM-EE-81-1980	Envases. Vidrio. Determinación de la resistencia al ataque químico
NOM-EE 92-1980	Envases y Embalaje. Vidrio. Envases aerosol no recubiertos. Especificaciones
NOM-EE-114-1981	Envases y Embalajes. Vidrio. Terminología
NOM-EE-124-1981	Envases. Vidrio. Clasificación de las coronas

NOM-EE-130-1981	Envases. Vidrio. Coronas de Rosca. Especificaciones
NOM EE 131-1981	Envases. Vidrio. Botellas para contener bebidas gaseosas. Especificaciones
NOM-EE-146	Envases. Vidrio. Coronas plastilata y corcholata. Dimensiones

DONE BY GLASS SUBCOMMITTEE

NOM-EE	Envase. Vidrio. Garrafones de vidrio. Especificaciones
NOM-EE	Envase aerosol de vidrio recubierto con plástico
NOM-EE	Envase. Vidrio. Determinacion del color del vidrio por transmitancia

REVISIONES RECIENTES

NOM-EE-12-1980	Envases de vidrio para productos medicinales de uso oral ó tópico
NOM-EE-27-	Envases de vidrio para cerveza
NOM-EE-32-1982	Envases de vidrio para bebidas alcoholicas en general

ANNEX IV

LANFI PERSONNEL ATTENDING THE TRAINING COURSE ON GLASS CONTAINERS

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A N N E X V

1. INTRODUCTION.

Many definitions have been given for glass, none of them - being completely adequate.

For our purpose it will suffice to state, that glass is an inorganic product of melting, cooled down to a rigid state, without crystallization.

Glass is sometimes referred to as an undercooled liquid. -- Thermodynamically this is not correct, but it gives neverthe less and idea of the "randomness" of the material on a molecu lar scale.

2. COMPOSITION

Glass can be made from many materials, including P_2O_5, GeO_2, As_2O_3, BeF_2, $ZnCl_2$, S, Se, etc. Although scientifically interesting, for glass containers they have no meaning.

Glass containers are based on the glass forming oxyde SiO_2 (silica) mainly.

Silica, however, has a melting point of more than 1700 C° -- and even at this high temperature it has a very high viscosi ty. To decrease the melting point, we introduce sodium oxyde, as a flux.

Unfortunately, Na_2O has the disadvantage of giving the glass a very poor chemical resistivity, so that it would dissolve - in water in a short time. Therefore we have to substitute - CaO, MgO and Al_2O_3 for part of the Na_2O.

This leads to the following composition for "normal" glass - containers:

SiO_2	71-74	weight %
Na_2C	13-16	weight %
CaO	7-11	weight %
MgO	0- 5	weight %
Al_2O_3	1- 3	weight %

We call this glass"soda-lime glass".

As an impurity there is always some Fe_2O_3 present. In flint glass (colourless glass) not more than 0,05%, but in green -- glass it can be as high as 0,4%. Iron gives a yellowish green colour to the glass. In flint glass this has to be compensated for by decolourants like a combination of Se + Co_2O_3C0,002 and 0,0002% resp. is usually sufficient).

A green colour , as used for emerald green containers, is -- produced by chromic oxyde

A brown colour, as used for amber containers is produced by introduction of ironsulphate, when melting under highly reducing conditions.

Blue is based on cobalt oxide.

Yellow, orange and red are produced by a combination of Cd and Se, or, in the case of red glass, by introduction of gold particles.

Although colourants are only needed in small quantities, we still have to be careful with the use of yellow, orange and red glass as food containers. The same applies for glazed ceramics and enamelled metal containers.

There is a second glass composition, used for containers in special cases, when a very high chemical resistivity is required. This glass is called "borosilicate glass". Most of the Na_2O has been replaced by B_2O_3 in this glass.

The approximate composition is:

SiO_2	80 weight %
B_2O_3	13 weight %
Na_2O	4 weight %
Al_2O_3	3 weight %

This glass is used for laboratory ware, ampoules, vials etc. It is sometimes called "neutral glass". It is also the advantage of a much lower thermal expansion coefficient than soda lime glass. It has, however, a higher price --

(B_2O_3 is more expensive than Na_2O), a higher melting -- temperature and a somewhat lower strength.

A word should be said about the used of lead in glass. It is not used in container glass, but it is in some tableware. This glass is known as "crystal glass" and the amount of - lead can be as high as 50% for the more expensive types. - It is used to create a high reflective index, a nice, sonore sound when touched, and a high transparency (no green or gray hase from iron here).

Regulations upon lead extraction have been made in many countries. The same applies-again-to glazed and enamelled ware.

Not all the glass, marketed as "crystal" contains lead, unless the government has regulated the permission to used the qualifications necessary to use names like "lead-crystal", half -- crystal", etc.

With the help of K instead of Na and Ba instead of Ca a "crystal-like" glass can be produced, perhaps not a brilliant as crystal, but close.

3. STRUCTURE OF GLASS

We can describe the structure of SiO_2- based glass as a -- three-dimensional random network of SiO_4^{2} tetraeders. The - Si^{4+} ions are surrounded by 4 oxygen ions. The oxygen ions form "bridges" between the Si-ions, so that a three-dimensional structure is formed. There is, however, no regular - pattern as would be the case in a crystal.

In slide 1, upper part, the structure of a pure $Si\ O_2$ - glass (quartzglass) has been represented, but for simplicity the Si - ions (black dots) have been surrounded by 3 oxygens - instead of 4.

In the lower part of slide 1 the effect of introduction - of Na_2O (or another alkali) is shown. The Na-ions fill the holes in the network, but at the same time some of the oxygen-bridges are broken. This creates flexibility in the -- structure, resulting in a lower melting temperature, but - also a lower chemical resistivity, Mg^{2+} and Ca^{2+} ions have the same effect, but to a lesser extend, since they have a valency 2 and consequently tie the oxygens closer together. P-ions, B-ions and Al- ions take the place of Si-ions in - the structure, so their function is somewhat different.

4. RAW MATERIALS

The most important raw materials for the oxydes, mentioned in chapter 2 are:

sand	(for $Si\ O_2$)
feldspar or nepheline syenite	(for $Al_2\ O_3$)

calcite	(for Ca 0)
soda	(for Na_20)
borax	(for $B_2\ 0_3$)
dolomite	(for Mg 0)

The requirements for these raw materials-apart from price - and regular supply - lye especially in the field of purity - and grain size distribution, not only in absolute value but also in fluctuation.

For instance, 0,5% Al_20_3 in sand is not necessarily harmful, as long as it is constant.

Since sand is the major component of glass and also one - of the most difficult components to "melt" (dissolve rather), requirements are most strict for sand.

As far as impurities is concerned, not only the $Fe_2\ 0_3$ --- content is important, but also the so-called heavy minerals, like rutile (Ti 0_2), chromite (Fe $Cr_2\ 0_4$) zircone (Zr Si 0_4), etc, because they colour the glass or dissolve very slowly or both. Generally not more than 0,2 g of heavy minerals in 100 kg of sand is allowed and no grains larger than 0,3 mm. Fortunately heavy minerals can be separated from sand by flotation or magnet separation techniques. The same holds, to a - certain extent for $Fe_2\ 0_3$. Ironoxide is allowed up to 0,03% for flint glass and up to 1% in green glass.

TABLE 1.

TYPICAL SET OF RAW MATERIAL SPECIFICATIONS FOR FLINT GLASS MANUFACTURING

MATERIAL	CHEMICAL COMPOSITION (WEIGHT %)	TOLERANCE (WEIGHT %)	GRAIN SIZE DISTRIBUTION
Sand	$SiO_2 > 99,0$	± 0,2	> 0,84 mm- 0%
	$Fe_2O_3 < 0,03$	± 0,01	> 0,59 mm- 1% max
	$Cr_2O_3 < 0,0003$		< 0,15 mm-15% max
	$Al_2O_3 < 0,3$	± 0,05	
Nepheline syenite	$Al_2O_3 > 22,0$	± 0.05	> 0,59 mm- 0%
	$SiO_2 < 62,0$		> 0,42 mm-3,5% max
	Alkali > 13,0	± 0,5	< 0,15 mm-35 % max
	$Fe_2O_3 < 0,10$	± 0,5	
Calcite and dolomite	CaO+MgO > 54		> 1,19 mm- 1% max
	$Al_2O_3 < 0,3$	± 0,1	> 0,84 mm- 15% max
	$Fe_2O_3 < 0,10$	± 0,05	< 0,15 mm- 20% max
Soda	$Na_2CO_3 > 99,0$		> 1,19 mm- 0%
	NaCl < 0,5		> 0,59 mm- 3% max
	$Fe_2O_3 < 0,001$		< 0,074mm- 3% max

Ideal grain size for glassmaking sand is around 0,3 mm or somewhat lower, depending on furnace conditions. Grains - lartger than 0,85 mm and smaller than 0,1 mm are generally avoided. Too large grains do not melt or dissolve quickly enough. Too small grains create dust, so blocking of regenerators and corrosion.

A typical set of specifications for the raw materials, used for flintglass, is given in table 1.

There are, in addition, quite some materials that are added in small amounts to the batch for several reasons, for instance:

- oxydators, like Na NO_3
- reducting agents, like C, S, Sulfides (for amber --- glass for instance).
- melting accelerators,like $Na_2 SO_4$
- refining agents (removing bubbles), like $Na_2 SO_4$ -- (for crystal and borosilicate glass As_2O_3 or Sb_2O_3 -- may be used).

In soda-lime glass the addition of $Na_2 SO_4$ is common, for - refining mainly (often combined with some Na_2S or C). We - cannot, in this context, discuss the physical-chemical phenomena created by these additions and their exact function.

5. MATERIAL PROPERTIES.

5.1 Mechanical Properties of Glass .

5.1.1 Strength

When discussing the mechanical strength of glass, we - always refer to the tensile strenght (or bending strenght). Since glass is a perfectly elastic material, breaking exclusively because of tensile stresses, mostly at the surface.

The condition of the surface is of extreme importance for the strength of a glass object.

A pristine glass surface can reach strength levels as -- high as 7500 kg $/cm^2$. An abraded glass surface, like from a returnable bottle after prolonged use, may have fallen back to no more that 300 kg $/cm^2$. Slide 2 shows the extreme variations we find in differente glass objects, depending on shape, use , forming method and, above all, surface condition.

The breaking strength of glass in handbooks on material properties is often given as 500 kg $/cm^2$. Is is, however, essential to realize that the standard deviation of the strength can easily be 20% or more.

In general: the more the glass has been abraded, the lower the standard deviation.

According to Griffith the tensile strenght is directly - related to the depth of the (micro) cracks in the surface according to the formula:

$$\sigma_m = \sqrt{\frac{2\gamma E}{\pi c}}$$

σ_m = Tensile strength

E = Modulus of elasticity

γ = Surface tension

c = Depth of the crack.

5.1.2 Static fatique

An extra complication, when defining the strength of - glass, is the fact the strength depends on the load du ration. We call this phenomenon "static fatique". It means, that if we apply a (tensile) load on glass for a long lime we will find that the material seems less -- strong than if we apply the load for a short time only. If we call σ_t the strength, belonging to a load duration t, we can write approximately:

$$\log t = a + b \log \sigma_t$$

Slide 3 shows the experimental curve, which fits this equation reasonably well.

Glass, when loaded for 24 hrs. will be approximately 50% weaker than if it is loaded for 1 sec. only.

The reason of this phenomenon is, that during loading the crack in the surface tend to grow slowly because of chemical attack at the crack tip by water vapour in the atmosphere. The atoms at the tip of the crack are under high stress, when a tensile load is applied to the glass and that makes this area very vulnerable for chemical -- attack.

According to the Griffith formula, given above, the tensile strength of glass σ_m decreases with increasing crack length c, so eventually, if the load duration is long --- enough, the glass will break.

Fortunately, this static fatique effect takes place only at load levels higher than a certain minimum (say 1/3 of the short time strength), so for not too high loads we -- cann neglect it. Is is clear, however, that it is a very important phenomenon when testing the strength of glass. - Also, it can become important for the packaging of carbonated liquids, if too weak containers or too high pres-- sures are used.

5.1.3 Hardness.

Hardness is important for scratch resistance. It is, -- however, not a property easy to modify by changing the - composition. All silicate glasses have a hardness, when measured on moh´s scale, between 5 and 6.

5.2 Optical Properties of Glass.

Glass under stress (compressive or tensile) becomes -- birefrigent. Physically this means that the light velocity in glass depends on the stress. Because of this property it is relatively easy to measure stresses in - glass (at least one-dimensional stresses) by making use of polarized light. What is measured, is the difference in velocity between two perpendicular light waves.

This difference is directly proportional to the stress. A polarization microscope and a compensator, with which the two light beams can be made equal again, are suffi-- cient for this measurement.

Glass no only transmits visible light (400-700 nm), but also ultraviolet light.

Flint glass transmits wavelengths higher than 300 nm,(emerald) green glass transmits wavelengths higher that 330 nm, amber glass transmits wavelengths higher than 450nm. Special UV- absorbing green glasses exist.

5.3 Thermal properties of Glass

For glass containers primarily thermal expansion is important, since it determines the thermal shock a glass - surface can withstand.

Soda-lime silica glass has a thermal expansion coefficient of about 90.10^{-7} m/m °C, borosilicate glass only 33.10^{-7} m/m °C.

As a consequence, borosilicate glass can withstand 2 - 2,5 times higher thermal shocks.

5.4 Chemical properties of Glass.

Soda-lime glass is very resistent, especially towards -- acid and neutral products.

The only reaction that takes place, is an exchange of -- Na^+ - ions in the glass for H^+ -ions from the liquid:

$$\text{Si-O-Na}_{(gl)} + H_2O \longrightarrow \text{Si-OH}_{(gl)} + \text{Na OH} \quad ...(1)$$

Since this is basically a diffusion process, the rate of alkali-extraction decreases with the square root of time.

From a 1 liter container in 6 months at 20 °C, no more - than 25 mg Na will be extracted. In most cases this can be completely neglected. However, at 100 °C this amount will be extracted in 1 hour only, so in sterilization -- processes of certain products and in the pharmaceutical industry it might become important.

In those cases the glass surface can be given a so called"sulfate treatment". At 500°C (in or before the annealing lehr) SO_2 is injected into the containers, giving rize to an alkali-depleted surface layer:

$$2\ Na^{+}_{(gl)} + SO_2 + 1/2\ O_2 + H_2O \rightarrow 2H^{+}_{(gl)} + Na_2SO_4$$

The sodium sulfate crystals can be washed away easily. - This process incereases the resistivity towards liquids with pH < 9 considerably. If this is not sufficient, borosilicate glass should be used. This glass contains - much less alkali and is still more resistant (see table 2)

In an alkaline environment (pH > 9) silicate glasses are less resistant , because then the glass structure itself is attacked:

$$\left[\begin{array}{c} \quad O \qquad\quad O \\ O - Si - O - Si - OH \\ \quad O \qquad\quad O \end{array}\right]_{(glass)} + 4\ OH^{-}_{(sol.)} \longrightarrow \left[\begin{array}{c} O \\ O - Si - OH \\ O \end{array}\right]_{(glass)} +$$

$$+ \left[\begin{array}{c} OH \\ OH - Si - OH \\ OH \end{array}\right]_{(sol.)} \qquad \ldots (2)$$

$Si(OH)_4$ goes into solution, so there is a weight loss, directly proportional with time.

Table 2 gives an estimate of the weight loss to be expected for glass in acid and alkaline environments at 25 °C and 100 °C.

TABLE 2.

WEIGHT LOSS DURING FIRST DAY IN mg / cm^2.

		in strong alkaline solutions	in strong acids and neutral solutions
Soda lime glass	20 °C	0, 1	0,001
	100 °C	10	0,01
Borosilicate glass	20 °C	0,1	0,0001
	100 °C	10	0,01

Special alkali-resistant glasses have been developed, containing up to 15% $Zr\ O_2$.

Reaction (2) is also important for weathering of glass. When water vapour condenses on glass at first reaction (1) will dominate. If the droplets are allowed to dry slowly, they will become more and more alkaline from the $Na^{\pm}$ extraction., so that eventually reaction (2) might dominate and the glass structure will be attacked.

If this process continues for a long time (for instance during storage of empty containers in a humid atmos --- phere combined with daily temperature changes) the glass can obtain a greyish appearance, which can be difficult or impossible to restore. (washing in H Cl might help, if the process is not too far advanced).

In tropical countries the sulphate treatment mentioned above, is sometimes applied, only to avoid this weathering phenomenon.

5.5 Viscosity of Glass.

Viscosity can be described as the resistance against -- flow. At room temperatures it has no physical meaning, since flow does not occur. It is a very important proper ty in the melting and forming process, though.

It is also important during annealing, that is the process to cool the glass in such a way that no (or rather no excessive) stresses develop in the material.

Slide 4 shows the dependence with temperature of viscosity. It also shows some important viscosity points. - The annealing point is defined as the viscosity where - stresses will disappear rather quickly and where the -- glass just begins to deform.

The strain point is defined as the viscosity, where - stresses will only disappear after a very long time. So in this temperature range the glass should be cooled very slowly to avoid temperature gradients in the - glass, since this would create stresses.

For soda-lime glasses this range is around 500-550 °C. For borosilicate glasses 20 °C higher.

6. MANUFACTURING OF GLASS CONTAINERS

6.1 Process description

Slide 5 shows the process of bottle manufacture schematically. Raw materials are weighed, mixed, fed into the -- furnace in a continuous process. Molten glass is taken from the furnace in small quantities, just enough for one container each and fed into the forming machine. After forming, the containers have to be annealed to remove or avoid stresses, and finally there is inspection and packing. We will discuss each step in more details below.

6.2 Batch Preparation.

Raw materials are weighed -usually automatically- according to the recipee and mixed in portions of about 2 tons. Good mixing is quite important and everything must be done to avoid segregation, e.g. separation between light and heavy or small and large particles, since that would --

make it difficult to make a homogeneous glass.

Segregation can also occur during transport of the - batch to the furnace.

6.3 The melting process.

A continous furnace (or "tank") as is used in container manufacturing consists of two rectangular rooms of high quality refractory bricks. The surface area can easily be 100 m^2, the depth of the glass bath is no more than about 1m (dependent on colour,a.o.).

Slide 6 shows a diagram of the furnace. The batch is fed continously into the furnace through an opening - in the wall, the so-called dog-house. The batch floats as a blanket on the molten glass.

In the first chamber (the "melting end") of the furnace, - the batch is melted and refined (removal of bubbles) at about 1 550 °C.

After that the glass is led through a narrow channel, - called the throat, into the second chamber, the "working - end". There the temperature is 100-200 °C lower and the glass is prepared further (made homogeneous for instance), before it flows into the feeder channels, connected to the furnace. There may 3 or 5 of these channels, --

depending on the size of the furnace. Here the glass - is brought at a temperature of about 1050 °C, to obtain the right viscosity for forming.

As an average the glass needs about 1 day to travel -- from the dog-house to the feeder channels, so flow is - really slow in a glass furnace. This is the time needed for proper melting.

The heat necessary to reach the high melting temperature is produced by gas or oilburners. The flames cover the surface of the glass batch, as shown in slide 7.

The hot flue gases disappear through a regenerator, which essentially consists of a chamber partially filled with bricks. Those bricks are heated by the flue gases and - after a certain time the system reverses: burners from - the other side of the furnace are ignited and the combustion air is supplied through the regenerator that has -- just been heated up. Flue gases now leave through the regenerator on the other side of the furnace. Every 20 minutes the system reverses. In this way the efficiency of the furnace has been increased considerable, since -- the combustion air can be heated to about 900 °C with -- this method.

6.4 Feeding.

Bringing the glass in portions from the furnace to the forming machine is the part in the process, which is the most difficult to automize.

The method that is generally used nowadays is called - "gob-feeding". Slide 8a shows the principle; slide - 8b the real situation for a double gob-feeder seen - from below. A ceramic plunger is moving up and down to push portions ("gobs") of molten glass through an - opening in the bottom at the end of the feeder channel. A knife, or better a water-cooled pair of scissors, -- cut the glass stream each time when the plunger goes up.

Control of gob weight occurs through a combination of speed of the plunger and glass viscosity.

6.5 Forming

Forming is usually done nowadays with the so-called I.S. machine, consisting of 6 or 8 independent forming sections. The gobs are led into those sections through a moving -- systems of metal gutters.

Often two or even three gobs can be handled by one --- section at the same time. We speak of a "double gob" - or "triple gob" machine in that case. Of course, the feeder also has three holes and three plungers then.

The gob falls into a cast iron mould, which does not - yet have the shape of the bottle to be formed. First the so called "parison" is made. It is like a balloon only slightly blown. The finish, however, has been - formed completely already.

The parison can be made by blowing (the "blow-blow process") or by pressing (the "press-blow process"). Pressing is preferable since it gives a better glass distribution, but it is not yet possible for narrow mouth containers, unless they are very light.

Slides 9 and 10 show the forming of the parison in the two processes.

Slide 11 shows how the parison is taken from the parison mould to the endmould or blowmould.

In this mould the container is blown to its final shape. See slide 12 a. Slide 12 b shows the whole process again in review. With one set of moulds about 3,000,000 containers can be made. Production speed varies from 50-300 per minute, dependent on container size.

6.6 Annealing

When the containers leave the mould they have a temperature of about 650 °C. If the were allowed to cool down in cold air, they would in the end break spontaneously -

because of stress.

A careful heat treatment is necessary to avoid this. In slides 13 and 14 this treatment is shown schematically. It is especially the temperature range between annealing and strain point (see section 5.5) that is important.

6.7 Surface treatments.

Before the bottles go into the annealing lehr, they can receive a so called hot-end coating. This is a very thin (50 Å) layer of tin oxyde or titanium oxyde, applied by pyrolyse of tin chloride vapour, isopropyltitanate or other compounds.

It protects the glass surface against abrasion and serves as a primer for the so-called cold-end coating (a stearate, polyaethylene, glycole, etc) that is applied by spraying when the bottles leave the annealing lehr at about 125 °C.

It serves to improve scratch resistance and lubricity.

This coating system has primarily been developed for non-returnable glass, since it is not adherent or strong enough to withstand washing and continuous abrasion. Nevertheless, systems for returnables have been develop ed that serve 3 - 4 trips.

6.8 Labelling .

Paper labels are most common, but for some container -- types more permanent labels are used. A paste of organic compounds containing tin, bismuth, iron, titanium - etc. is applied to the container surface in a screening process at room temperature. It is essentially a glazing process. The glaze has to be heated to around -- 500 °C to melt and form a glass to adhere strongly to the glass surface.

6.9 Inspection.

Inspection still occurs visually and by sampling (and testing according to the methods described in chapter 8) but nowadays several types of in-line inspection machines are in use. In those a 100% detection is possible for cracks, bird wings, height, diameter, wall -- thickness, perpendicularity, mouth bore and even some strength aspects ("squeeze tester").

There is hardly a factory that uses all available equipment on all lines, but the necessity of this kind of - inspection is felt more and more.

6.10 Other Manufacturing Methods.

Small series of cosmetic containers (special design) and also very large containers are often made semi-automatically with smaller furnaces where the glass is gathered - by hand (that is, taken out of the furnace with a long - metal stick or tube) to be put into the mould.

Ampoules and vials are usually made from borosilicate - tubing, prepared before.

7. DESIGN OF GLASS CONTAINERS. TECHNICAL ASPECTS .

7.1 Terms used to define bottle parts.

Slide 15 summarizes the most important terms to describe parts of a glass container.

We distinguish mainly between the finish (with the bore, the sealing surface, etc), the neck, the shoulder, the body, the heel or insweep and the base with the push - up.

A glossary of more terms, used in glass industry, is -- given in appendix I.

7.2 Design related to product.

Design must be suitable for the product. Solids and semi-solids must be easy to get in and out. Soft curved shoulders may increase filling speed, especially for - carbonated liquids. Chemical properties fo the material may effect the choice of the closure.

7.3 Head Space

Head space or vacuity is defined as the difference between brimful and nominal capacity.

Head space is needed to make sure that the container - does not become completely full when the temperature - rises, since that could create very high pressures. It is especially important when packing liquids. Water expands 4% when heated from 4°till 100 °C.

As an example let us take a one liter bottle filled - with liquid. First one should define the maximum temperature to be expected. This could be the pasteurization temperature or just the temperature that could -- occur during transport or storage. Then the expansion of the liquid has to be known, (expansion of glass can usually be neglected).

Suppose maximum expansion of the liquid (1L) is 30 ml. How large whould the head space be in that case. 30 ml will certainly not be sufficient. First of all there is a spread in the filling level. The maximum level to be expected -- should be taken into account. So, if the filling level for instance variates $\pm$ 2 mm., it should be calculated - how much this is in volume ($\pi r^2 h$). If the radius of the neck at filling height is 25 mm, this would mean a variation in filling volume of $\pm$ 4 ml.

Consequently the head space should be minimal 34 ml. -- However, the bottle neck and bore will have some varia - tion too. This will lead to a variation in bottle head space itself. Suppose the variation in bottle head spa ce capacity is $\pm$ 2 ml, then the average head space should be fixed at 1036 ml minimum.

If in a certain case all variables would add up in a ne- gative sense, the bottle could still be completely full, however. For a hermetic closure, Boyle Gay Lussac's law $\frac{PV}{T}$ = constant would still predict an infinite pressure in such a case.

So, a maximun allowed pressure has to be defined (depending - on bottle strength) and then V minimum can be calculated.

If the head space is filled with a gas that dissolves in to the liquid easily, like CO_2, Boyle Gay-Lussac's law - would not apply and the pressure would mainly depend on temperature. Still, one has to be sure that equilibrium is attained in a short time.

ior carbonated liquids, especially soft dinks, there - is not only a minimum head space to be considered, but preferably also a maximum. The pressurized gas in the head space delivers the energy of the "explosion" in - case of breakage, and this energy is roughly proportional to PV. A small headspace, therefore, decreases injury risk in case of breakage.

7.4 Thermal Shock Resistance.

Thermal shocks occur during washing, hot filling, pasteurization etc, It creates transient stresses in the glass, since the wall does not have a uniform temperature. Tensile stresses will occur in areas with - the lowest temperature. A hot surface, suddenly cooled, is the most dangerous, especially if this surface is the outside (abraded) surface.

A thermal shock from a low to a high temperature can - be roughly twice as large is viceversa.

Wall thickness is a very important factor as is shown in slide 16 a.

A thin wall is favourable for thermal shock resistance.

Most problems occur in the area of the heel, since there is a rather sudden change in wall thickness, going from body to base. Thermal breakage often shows as a simple crack, separating the base fromm the body.

It is important to design a container in such a way that too sudden changes in wall thickness can be avoided, for instance by giving the bottle a gentle insweep.

7.5 Internal pressure resistance.

The most important question is: will there ever be pressure in the container and if so, how high and how long.

Pressure not only occurs in containers filled with carbonated liquids, but may also occur during pasteurization and sterilization of other products.

In general a cylindrical container is the best (not -- counting a sphere, of course). It can withstand roughly a 10 times higher pressure than a square bottle with - sharp edges (4 times more if the edges are rounded).

The stress σ in the wall, created by the internal pressure depends on $\frac{D}{d}$, if D is the body diameter and d the wall thickness. So, contrary to thermal shock - resistance, a thick wall is better. Also, a short, -- bulky bottle can withstand pressure less than a slim, high bottle. Stability, however, sets a limit here.

In principle, the relation $\sigma :: \frac{D}{d}$ is valid for a - (perfect) cylinder only. A well designed shoulder pro file may increase pressure resistance.

Slide 17 shows how shoulder profiles can influence the stresses in certain areas of the body. It can be use- ful to design the contact zone in the region where stres ses are minimal. It requires a computer program, however, to realize this.

When designing a bottle for a certain internal pressure -- resistance, the strength decrease, due to abrasion has to be taken into account.

Slide 18 shows how fast pressure resistance falls down in the first year of service of a returnable bottle -- (assuming a "normal" number of trips per year). The va lue finally goes to rougly 1/2 of the original value -- (first cracks have the most influence). The curve of sli de 18 shows the average bursting pressure. The minimum value to be found when a large number of containers - were tested, will decrease less. the values could be -- (for instance) as follows:

Bursting pressure	brand new	as delivered	after prolonged use
average	24	14	10
minimum	16	9	7

7.6 Vertical load resistance.

Vertical load occurs during closing and possibly in storage or transport. Bottles are not complete equal in height, so the load when placing trays or crates on top of each other, will not be evenly distributed over all containers.

Design is important here too. Slide 19 shows that a large vertical radius of curvature at shoulder or heel is favourable, as one would indeed expect.

7.7 Impact resistance.

When a hard object hits the glass container, in several places tensile stresses will develop.

Figure 1, added to this report, shows a cross section of a cylindrical bottle, hit by a hard object.

High contact stresses develop in the (small) contact area between glass and object. There will be bending stresses at the inside surface under the contact area and there will also be the so-called hinge stresses in a relatively large area on the outside surface, at some distance from the place of contact. Hinge stresses occur because the cylinder deforms elastically during impact.

Usually breakage is due either to contact stresses or to hinge stresses. Bending stresses only lead to breakage in very thin-walled containers or if the inside surface has been damaged.

Contact stresses dominate in rigid walls with little possibilities for bending. A thick wall , a small diameter and a square shoulder favour the development of contact stresses. This situation is shown on the right hand side of slide 20.

Hinge stresses develop strongly in containers that can deform elastically under impact. A thin wall, a large diameter and a large vertical curvature of the shoulder favour hinge stresses. This situation is shown on the left hand side of slide 20.

The highest impact resistance is found when both breakage types are just as likely to occur. This optimum -- (middle past of slide 20) depends on wall thickness -- (and diameter) as well as shoulder design. A good shoulder design can give more than 25 % increase in impact - resistance, compared to a straight cylinder.

When a container is hit at the heel, the situation is somewhat different usually, since the wall will be too thick in this area to develop hinge stresses. If the -

body remains straight down to the base, so that bottles can hit each other at the heel, large cracks may develop (so called "butterflies"),extending from the impact place into the base.

For that reason, the insweep should begin at some distance (10-15 mm) from the base, to avoid this phenomenon.

7.8 Optical transmission.

In general the choice is limited to green, amber and flint. The choice depends on product presentation and on product sensitivity for light (UV light especially).

Tranmission curve for amber glass is shown in slide 21. Similar curves exist for green and flint glass.

7.9 Closures

Important features are:

- No solid, liquid or gas shall escape from the bottle or penetrate into it.
- Closure materials (liners) should not react with the product.
- The user must be able to get to the contents easily.
- The closure may have to make a good re-seal.
- The closure may have to be pilferproof.
- The closure may have to be "child proof".
- The closure should preferably enhance the appearance of

the whole pack.

Technically, closures may be classified in three groups.

1. Normal seals (screw cap, lug cap, cork, lever cap).
2. Vacuum seals (screw cap, twist-off, pry off, omnia, roll-on).
3. Pressure seals (crown cork, screw cap, roll-on).

Finish tolerances should be as small as possible to facilitate proper sealing.

8. TESTING AND QUALITY CONTROL OF GLASS CONTAINERS. METHODS AND SPECIFICATIONS.

8.1 INTRODUCTION

In the glass factory there are several ways to control the quality of the product. Apart from all kind of -- process control (necessary to obtain a good glass) -- the quality is checked by inspection of a certain number of containers per hour production from each mould.

This type of inspection uses the same methods as described below for input control. Nowadays in-line inspection equipment is used, which allow a 100% inspection on several aspects. In fact each year more types of inspection become available. However, proper operation of -- this sophisticated equipment requires great skill and - therefore inspection by sampling remains needed.

Input quality control by the customer or any other organization that wants to get information on the quality of the glass containers has, of course, to be done by -- sampling techniques.

Generally, the tables of the Military Standard 104 D -- (inspection by attributes) or 128 (inspection by variables) are used to establish sample size. Military Standards offer 6 levels of accuracy, so the simple statement "sampling is done according to Military Standard " gives no information at all on accuracy of the results, only on the method.

Generally, inpection level 2 is recommended. However, a lower level (which always means smaller samples) can be used in some cases.

Inspection by variables is possible only for measurable defects, since an average and standard deviation of the sample are needed. The advantage of inspection by variables is the smaller sample size required, compared with inspection by attributes to obtain the same accuracy.

Inspection by variables is only allowed for defects -- with a normal (gaussian) distribution, which in general creates no problem for glass.

8.2 Visual Defects

Slide 22 shows the three kinds of visual defects, with their definition and some examples.

A. Critical defects.

These include all defects, creating danger to consume glass particles, like spikes and "birdwings". in the container. Of course this applies mainly for food and drinks.

AQL (Acceptable quality level) for the defects -- should be as low as possible to reduce consumer -- risk. AQL = 0,065% is a usual figure, but in practice the discovery of one container in a lot with a critical defect should (and generally will) lead to rejection of the whole lot.

B. Major defects.

These include all visual defects that make the container useless for packaging, like stones in the -- glass, deformation of finish or base, etc.

AQL is generally 1%, but in some countries lower -- level are required by the bottlers, since 1% defects creates far too much stagnation on high speed filling lines.

C. Minor defects.

These defects mainly effect appearance. For cosmetic glass, however, they are often considered as major defect.

AQL is usually 4%.

Since visual defects cannot be measured exactly, a collection of "limit samples" has to be made and agreed upon with the supplier to compare and decide whether a certain container is defective or not.

8.3 Dimensional defects

In fact these are also major defects, but it can be handy to treat them separately, since they can be measured.

AQL for these defects is generally 1% (with the same remark as for major defects) for each type of defect separately.

A list of the dimensions that are usually checked, together with the tolerances allowed in Europe and USA (very --- roughly), is given below.

- Weight 200g $\pm$ 9

  500g $\pm$ 15

  Weight is often not specified very accurately, since it is considered of less importance than capacity and the manufacturer uses weight to control capa city.

Some customer measure weight as an indication of capacity,but the reliability of this method is -- not very high.

- Capacity. $\leqslant$50 ml ± 3,5 ml,
  500 ml ± 11
  1000 ml ± 15 (for non-cylindrical containers ± 22,5)

  Nowadays often:
  1000 ml ± 10.

Capacity is measured by weighing the containers empty and filled with water (20 °C). Specific weight - of the water (including air and salt content) should be taken into account.

Height. $\leqslant$ 50 mm ± 0,6
100 mm ± 1,0
300 mm ± 1,8

Height can be measured exactly or checked with a caliper (go, no-go).

- Diameter, $\leq$ 40 mm $\pm$ 0,8
  70 mm $\pm$ 1,4
  100 mm $\pm$ 1,8

It is measured or checked with a caliper.

- Out-of-Roundness. 2 times diameter tolerance. For soft drink bottle 1,5 times, since there out-of-roundness creates stresses (bottle tries to -- become cylindrical)

It must be measured as the difference between maximum and minimum diameter in one cross section.

- Finish. Very precise drawings exist for most closures. An example is given in figure 2.

Usually in input quality control only the outside diameter is measured.

For narrow mouth containers : $\pm$ 0,3
For wide mouth containers : $\pm$ 0,4 or 0,5

- Bore. Only a minimum is usually required to make sure that the filling pipe can enter.

- Internal mouth diameter. In some cases sealing -- occurs with a plastic insert in the first part of the bore. In that case there may be an additional requirement for the internal mouth diameter, usually between 0 and 3 mm from the sealing surface.

For internal mouth diameter < 5 mm $\pm$ 0,2
For internal mouth diameter 20 mm $\pm$ 0,5
For internal mouth diameter 40 mm $\pm$ 0,7

Perpendicularity This is the agreement of the vertical axis of the container with a line 90 degrees to its base. It is measured by turning the bottle - round and observing the horizontal movement of the finish.

Up to 120 mm container height: max 1,5 mm. $>$120 mm : 0,3 + 1% of the height, with a maximum of 3,3 mm.

Wall Thickness. Several types of equipment are available, based on optical or capacitive principles.

The most reliable is still simple mechanical measurement, if necessary after cutting the bottle. A minimum wall thickness to be found anywhere in the container is usually specified.

For containers made for non-carbonated products 1,0 mm and 1,2 mm are usual figures for non-retur nable and returnable containers respectively.

For soft dirnk bottles 2,0 mm may be required. - Often there is also a dependence on bottle diameter.

Coatings. Thickness of hot end coatings may be - measured with a special device, developed by American Glass Research. A thickness between 40 and 100 Å - is usually considered adequate.

For bottles capped with crown cork there may be an additional requirement that no coating is allowed on the finish, since tin oxyde has been found to - give rise to oxydation of the crown cork.

A special coating thickness meter for the finish - has also been developed by AGR.

Cold end coating quality is usually measured with a tilt table, where the angle is measured where one bottle starts to glide over two others, on which it is resting. Specifications depend on coating type but the slip angle should be much lower than for - uncoated bottles.

- Ondulated sealing surface. This aspect applies to jars mainly. Too strong ondulation will prevent good sealing.

A long, but "weak" ondulation is less dangerous - than a short sharp ondulation. Therefore, not -- the depth of the ondulation as a whole needs to be specified, but rather its change of depth per degree of the circumference of the sealing surface. The following specification is usually adequate:

The distance between the real surface at a certain point and an imaginary flat plane through (the -- greater part of) the sealing surface may not change more than 0,1 mm when we move 22,5° along the - circumference of the sealing surface.

Exact measurement involves determination of the -- height of the jar at each point of the sealing --- surface. A quick check can be made by placing -- the jar upside down on a flat surface an trying -- to put a thin metal strip between glass and supporting surface.

8.4 Cooling Stresses.

Cooling stresses are measured with a polariscope, comparing the colours that become visible in a stressed container with prestressed discs.

Containers with and without stresses are shown in slide 23.

A colour, comparable with 4 discs, is generally allowed, not more.

The method is described in ASTM C148-77. It should be made clear that this method may give erroneous results, since only the net stress in the wall (two walls even, unless the base is viewed) can be seen. Compressive - and tensile layers may cancel each other out.

For exact measurement is necessary to cut a ring out of the container body and to measure the stress with a polarization microscope and a suitable compensator. (Berek, Babinet).

8.5 Thermal shock test

This test has been fully described in ASTM C 149-77.
A shock of 40-42 °C is usually required.

In some countries there is an additional test for containers meant for hot filled products.

In that case the containers have to withstand filling with hot water (product temperature).
AQL is usually 1%.

8.6 Internal pressure test

This test has been fully described in ASTM C 147-76. - Standard equipment is available form AGR. In section - 5.1.2 the strength dependence on load duration has -- been discussed. To avoid confusion, an international agree ment has been made to give all bursting pressure figures for a 1 minute load duration. Most apparatus measure -- must quicker, but the results are presented for 1 minute load. This has to be kept in mind when specifications - have to be made. Load duration in a soft drink bottle - is much larger than 1 minute. The following table gives approximate conversion factors * (see also slide 3).

Loading interval	Relative bursting strength compared to 1 minute duration
1 second	135 %
1 minute	100 %
1 hour	80 %
1 day	72 %
1 month	70 %
1 year	68 %

* Exact figure were not available while writing this report.

The specifications for bursting pressure depend on the carbonation level of the products the container are -- meant for. (for jars there is usually no specification).

The following table shows some figures.

BOTTLES FOR	NON- CARBONATED LIQUIDS	LOW-CARBONATED LIQUIDS	HIGH CARBONATED LIQUIDS
Returnable use	8,0	12,0	15,7
No returnable use	6,0	10,0	14,3

The figures are given in $kgf/cm^2/min$. Non-carbonated means a pressure lower than 0,15 kgf/cm^2 mesuared at 20 °C. AQL for non- and low-carbonated-liquid bottles is 1%. For --- bottles meant for high-carbonated liquids it is 0,65% usually.

8,7 <u>Vertical load test</u>

For this test there is an apparatus available from AGR as an addition to the bursting pressure tester. Also in this --- case, values should be corrected to a 1 minute load duration.

Specifications depend on closure type, since vertical load especially occurs during closing.

For bottle "normal"	250	(kgf/min)
For bottle with crown cork	700	(returnables)
For bottle with crown cork	600	(non returnables)
For bottle with roll-on cap	500	
For jars normally	250	kgf/min.

(omnia 350)

AQL for vertical load resistance is 1% usually.

8.8 Impact resistance test

Impact resistance is usually not included in container specification, since there exists no reliable measuring method to compare results universally. It is a diffi -- cult property to measure. However, in design studies it is indispensable. A glass laboratory should have equip ment to perform impact tests (available from AGR), but - results should be for internal use only, to compare dif ferent bottle designs for instance. There should be -- strict rules how the test is to be done, for instance - how many blows per dropping height of the hammer, how - far apart the blows should be (never more than 3 at a - cross section to avoid cracks in the hinge stress zone of another blow), how the bottle should be clamped, and so on.

8.9 Chemical resistivity.

Generally this is not included in normal input quality control, though it may in the case of pharmaceutical - glass, as far as alkali extraction is concerned. Methods are described in the American Pharmacopee and in ASTM - test C 225-73. For alkali extraction, container glass is subdivided into 3 groups. Type 3 is the normal soda lime glass. Type 2 is also soda lime glass, but with improved surface properties to obtain lower alkali extraction --- (sulphur treatment. See section 5.4).
Type 1 is borosilicate glass.

Alkali extraction of type 1 and 3 is determined after --- crushing the glass. For 30 min. the glass is placed in - an autoclave at 121 °C with 50 cm^3 demineralized water. - With 0,02 N H_2SO_4 the amount of alkali extracted from -- the glass powder, is determined:
Specifications are:

Type 3 glass:	max 8,5 ml	0,02 N acid
Type 1 glass:	max 1,0 ml	0.02 N acid

For surface treated glass the test has -of course- to be done on the container as such, not on powder. The bottle is filled up to 90% of the nominal volume with demineralized water and placed in the autoclave for 30 min.at 121 °C.

Specification in this case:

Type 2 glass (surface treated).

for nominal capacity $<$ 100ml : max 0,2 ml 0,02 N acid

for nomical capacity $>$ 100ml : max 0,7 ml 0,02 N acid.

Extraction of other elements than alkali is not a matter of concern for "normal" container glass. Lead extracion should be determined from crystal glass, cadmium and -- selenium from red, yellow and orange glasses if those - glasses are likely to be used as food containers (table ware).

The same applies for glazed ceramics and enamelled ware. Test methods and government specifications have been set up in several countries for this, for instance in Germany and the Netherlands.

8.10 Optical Transmission.

In many cases colour of the container is only mentioned - in the specification, not specified and not included in - quality control. Some factories have agreed upon limit - samples to check colour visually. Colour, however, depends rather strongly on wall thickness.

If colour is chosen in connection with light protection - for the product, a more precise specification may be required.

Sometimes the whole transmission spectrum between 300 and 1000 nm is defined within certain limits, as for - instance in slide 20, usually for wall thickness 2 mm. (so a correction for the real wall thickness is needed).

Method and specifications for pharmaceutical glass are given in the American Pharmacopee . If only UV protection is important, a maximum permitted percentage transmission in the range 290-450 nm is sometimes considered sufficient. For instance, for a 10 ml medicine bottle max 13% transmission in this range may be allowed.

Green glass is sometimes defined by the transmission value at 550 nm only, since the general trend of the transmission curve is relatively stable and only shifts up and down.

9. RECOMMENDED LITERATURE

1. B.E. Moody "Packaging in Glass", 1977 (2nd Edition).

2. O. Cardon, "Le verre dans les industries Alimentaires", 1974.

3. H. Rawson, "Properties of Glass", 1981.

GLOSSARY

The following are the meaning of terms used in the glass industry.

AQL (Acceptance Quality Level) -	The maximum percent defective (or the maximum number of defects per hundred units) that, for purposes of sampling inspection, can be considered satisfactory as a process average.
Annealing	To prevent or remove objectionable stresses in glassware by controlled cooling from a suitable temperature.
Bearing Ring -	The portion of the base which contacts the surface when bottle is in an upright position. The contact area is on or adjacent to the outer circumference of the container.
Ellipticity -	The imperfection of nonroundness of the bottle.
Finish -	The portion of the bottle above the neck.
Internal Pressure Resistance -	The ability of the bottle to withstand forces applied to the inner surfaces.
Knurling -	A pattern of small projections on the bearing surface.
Locking Ring -	The part of the bottle finish which engages the cap or closure.
Out-of-Roundness -	See Ellipticity
Perpendicularity -	Agreement of the vertical axis of the bottle with a line 90 degrees to its base.
Removal Torque -	Force in inch pounds required to twist closure when removing it from container.

Root of the Design (or Flute) - The grooved portion of the decoration.

Stress - Any condition of tension or compression existing within the glass, particularly due to incomplete annealing, temperature gradient or inhomogeneity.

Surface Coatings - A protective substance applied to glass surface to improve its performance.

Temper - The degree of residual stress in annealed glass measured polarimetrically or by polariscopic comparison with a standard.

Thermal Shock Resistance - The relative ability of the bottle to withstand breakage when transferred from a hot solution to a cold solution.

Glossary of BOTTLE IDENTIFICATION MARKS

Item Number - That number assigned by a manufacturer to identify a unique bottle design. This number will not change with cavity or manufacturing plant, but will vary with manufacturer.

Job Number - Same as item number.

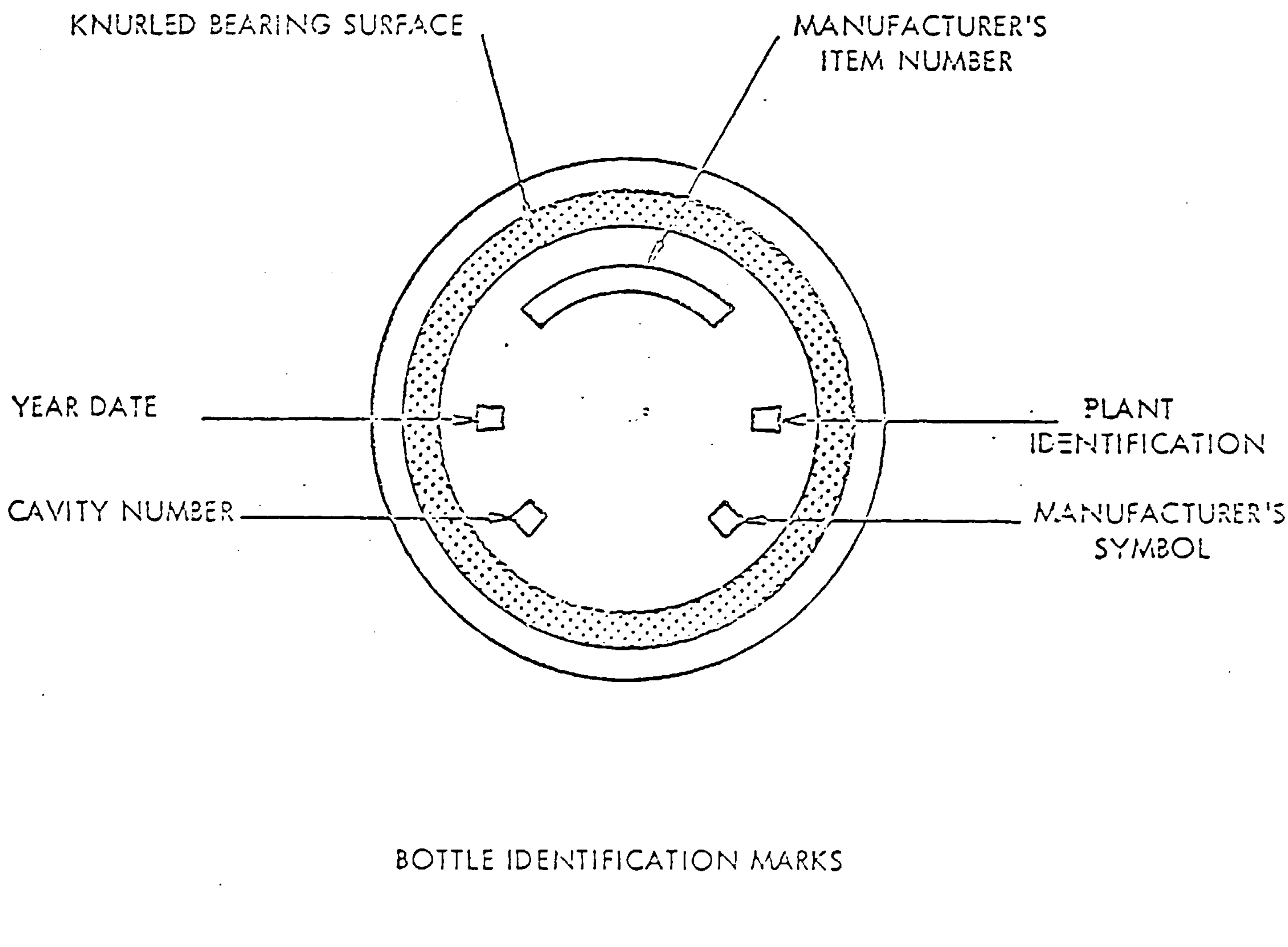
Mold Number - That number assigned by a manufacturer to identify a single blow mold out of a set of mold equipment. This number may be the same as the cavity number if the iron that comprises the mold has only a single cavity. If, however, a mold has two or three cavities, those cavities will, in many cases, be identified by the mold number followed by a dot or two dots.

Cavity Number - That number that identifies the unique opening in a blow mold that forms the bottle. Each cavity in a set of mold equipment will have a different number.

Plant Identification - That numeric or letter symbol that identifies the manufacturing plant.

Year Date - The last two numbers of the year of bottle production, i.e., the year 1970 will be represented by 70.

Manufacturer's Symbol - That mark which identifies the company that manufactured the bottle.



BOTTLE IDENTIFICATION MARKS

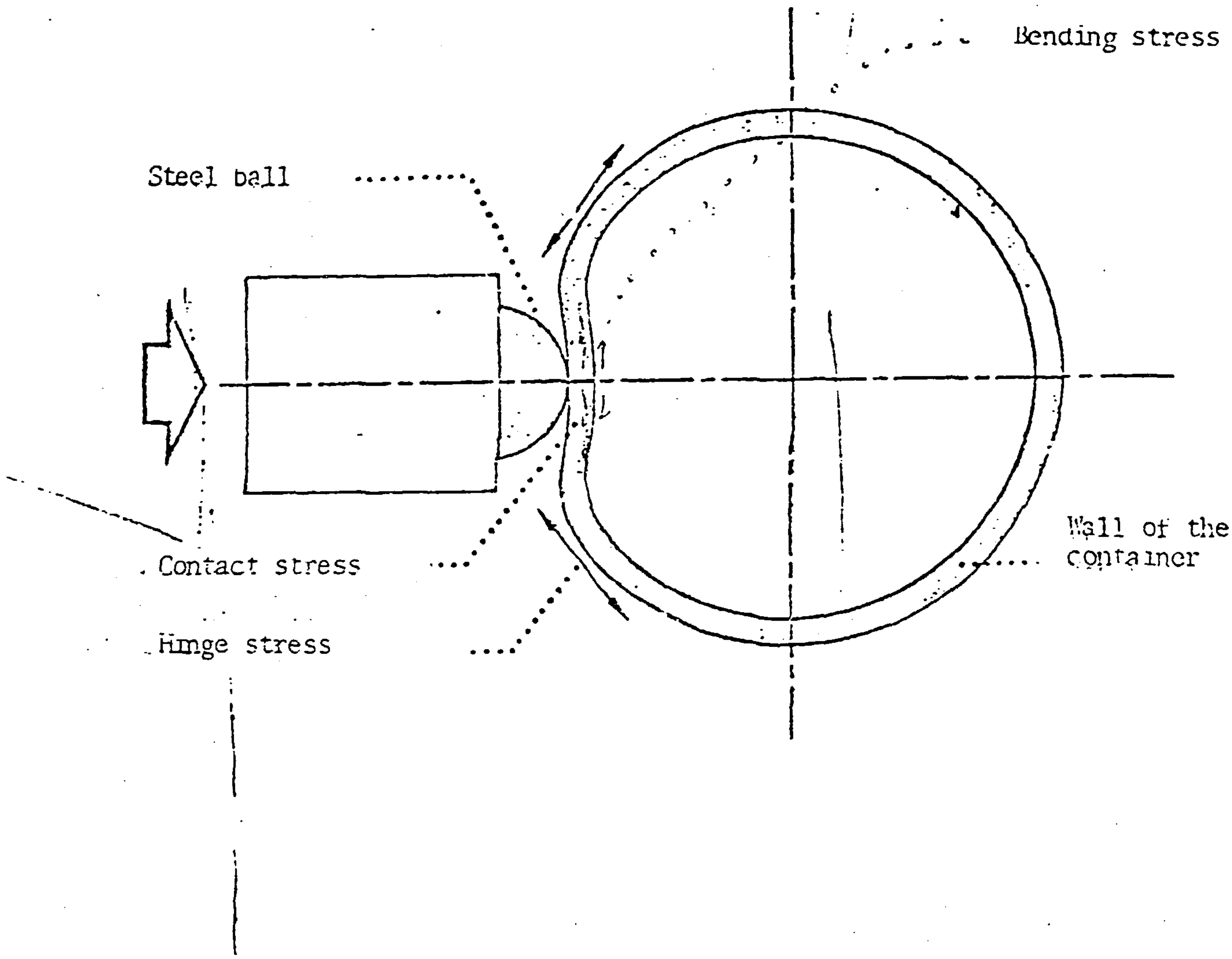


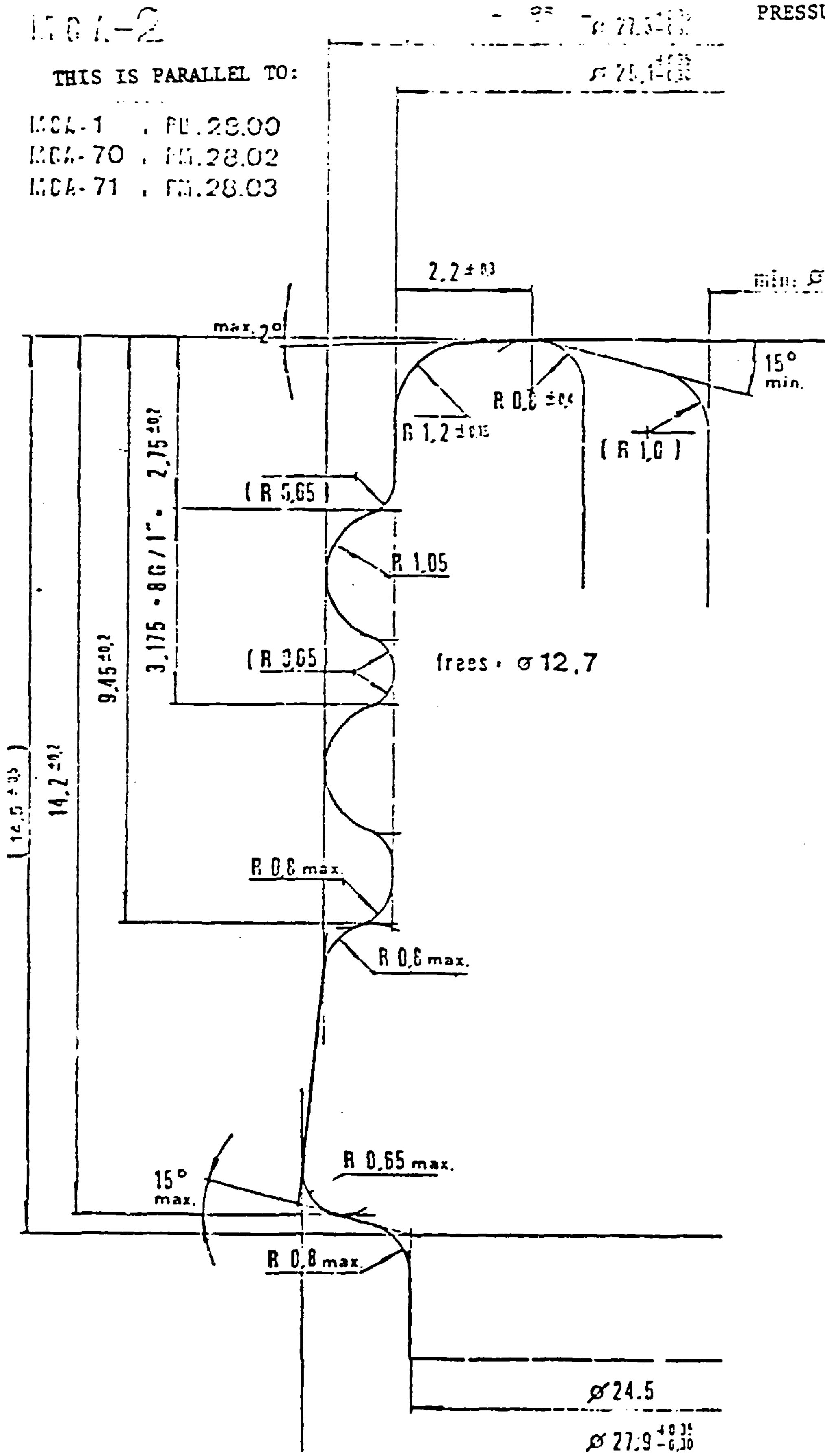
FIGURE 1. IMPACT OF GLASS CONTAINER

PRESSURE RESISTANT SEAL

MCA-2

THIS IS PARALLEL TO:

MCA-1 , FB.28.00
MCA-70 , FM.28.02
MCA-71 , FM.28.03



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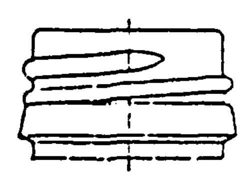

FIGURE 2. EXAMPLE OF FINISH SPECIFICATION

SLIDES

1. Structure of glass.
   Upper part pure silica glass
   Lower part soda (lime) silica glass.

2. Table to show strength variation with surface condition.

3. Static fatique effect on internal pressure resistance of glass containers.
   Effect of loading interval on bursting pressure

4. Viscosity -temperature relation of soda- lime silica - glass.

5. Glass container manufacturing process.

6. Cross sections from side and top of a continous glass -- furnace.

7. Transverse cross section of glass container furnace, flames and regenerators.

8a. Schematic presentation of gob feeder operation.

8b. Double gob feeder, seen from below.

9. First stage of the blow-blow process (blowing parison).

10. First stage of the press-blow process (parison pressing).

11. Transfer from parison mould to blow mould.

12a. Final blowing of the container.

12b. Bottle making in review (blow-blow process).

13. Annealing process. Temperature-distance relation.

14. Annealing process. Temperature-time relation.

15. Glass container terms

16. Relation between wall thickness and thermal shock resistance.

17. Circumferential surface stress (tensile) in the shoulder area of containers under internal pressure for several shoulder designs.

18. Internal pressure resistance ("barstdruk") as a function of bottle age ("leeftyd in jaren") in years.

19. Vertical load resistance as a function of shoulder design.

20. Impact resistance as a function of shoulder design

stootweerstand = impact resistance

scharnier spanning = hinge stress

contact spanning = contact stress

21. Optical transmission as a function of wavelength for amber glass, including limit specification.

22. Visual defects in glass containers. Definitions and examples.

23. Cooling stresses in a glass container, seen through a polariscope. Upper bottle no stress, lower bottle high stress.

ANNEX VI

SEMINAR

ENVASES DE VIDRIO EN MEXICO

Lecturers

Q.F.B. Alfredo Acuña
Research and Development Manager
Cía Comercial Herdez, S.A.

Dr. Henk de Waal
United Nations Industrial
Development Organization Expert

Ing. Humberto Gordillo
Cervecería Modelo

Dr. José Luis Herce Vigil
LANFI

Dr. Chaim Mannheim
United Nations Industrial
Development Organization Expert

Ing. Ricardo Tejada
Grupo Vitro

Ing. Faustino Villarreal
Grupo Vitro

PROGRAM

August 5

9:00 - 9:30	Introduction
9:30 - 11:00	Technological aspects in the design of glass formulas for container manufacturing. Ing. Faustino Villarreal Grupo Vitro
11:00 - 11:15	Break
11:15 - 12:15	Use of glass packaging in bottling plants Q.F.B. Alfredo Acuña Cía Comercial Herdez, S.A.

12:15 - 13:15	Use of glass packaging in Food Industry Ing. Humberto Gordillo Cervecería Modelo
13:15 - 15:00	Break
15:00 - 16:30	Quality control in glass packaging industry Ing. Ricardo Tejada Grupo Vitro
August 6	
9:00 - 10:30	Properties of glass containers and ways to improve them Dr. Henk De Waal UNIDO expert
10:30 - 11:30	Preservation of food in glass containers Dr. Chaim Mannheim UNIDO expert
11:30 - 13:00	Design of glass containers. Technical aspects Dr. Henk De Waal UNIDO expert
13:00 - 15:00	Break
15:00 - 16:30	Quality control, standardization and legislation of glass containers in the Netherlands Dr. Henk De Waal UNDIO expert
16:30 - 17:00	Conclusions and recommendations
17:00 - 17:30	Closure

ANNEX VII

DESIGN OF GLASS CONTAINERS. TECHNICAL ASPECTS.

1. Introduction.

Glass containers exist in a great variety of designs. Jars and bottles are most common, narrow - as well as wide mouthed types, returnables as well as non - returnables. However, cosmetic glass, pharmaceutical glass, vials, ampoules and glass aerosols must be considered as glass containers too, and so are the large demi-johns (23 l) and carboys (45 l).

2. Factors to consider when designing a glass container.

2.1 Bottle capacity

We distinguish between the nominal and the brimful capacity. The difference is called headspace or vacuity, usually expressed as a percentage of the nominal capacity.

The commercial department may want the bottle to look as full as possible, technically it is essential to allow for expansion of the product when heated.

In an air-tight pressure-sealed container the pressure may become intolerably high if the temperature is raised and the headspace becomes too small. Water expands 4% when heated from 4° C to 100° C and glass not more than 0,1%!

In case the headspace contains a gas, which is not or only slightly solvable in the liquid (like air), Boyle Gay-Lussac's law ($\frac{P \times V}{T} = \text{const.}$) will give the pressure to be expected during heat treatment (sterilisation) or in storage and the glass manufacturer can provide information whether this pressure is allowed.

In cases where the headspace contains a gas, solvable in the liquid (like CO_2), headspace size may seem less important but it is good to realise that equilibrium may take long to be established without vigorous shaking of the container.

In general, never allow the container to become completely full. A headspace of 3 till 4% will generally be sufficient. On the other hand, for carbonated liquids the headspace should also not be chosen too large to limit the potential energy of the entrapped gas, which will become free in case the bottle would break accidentally. A headspace of 4,5% is usually considered as a maximum. Vacuum-sealed food packs generally require much larger headspace (6-12%) to avoid over-pressure during temperature rise and consequent loss of sealing properties.

When calculating the required headspace, the spread in filling height and bottle-neck volume also have to be taken into account.

2.2 Type of substance to be packed.

Filling of solids and semi-liquids may require special design. The container must be easy to fill and to empty. Products like jam, peanut butter, honey and some sauces will be got out with a spoon or a knife.

The opening should be large enough and the container should not have "hard to get at" corners.

When selecting a container for a certain product, the glass colour may also play an important part. Some products will look unattractive in green and amber glass. Other products may

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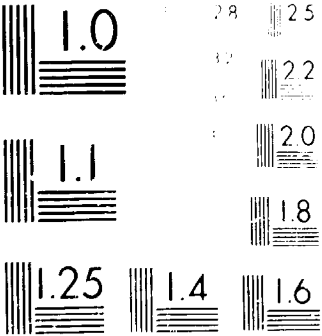
1.0
2.8
2.5
2.2
2.0
1.1
1.8
1.25
1.4
1.6

be attacked by ultraviolet light (beer, some pharmaceutics), and amber glass may be required or other precautions taken. For most container types the choise, however, will be limited to flint, (emerald) green and amber. Most glass manufacturers just will not produce other colours, since it is not easy to change the glass colour in a furnace.

For cosmetic glass spraying of tinted organic layers on the surface has become more economical.

2.3 Shape and dimensions

Usually there are clear limits imposed by the type of machinery present in the bottling plant.

Stability of the container must be sufficient to avoid tipping over on the filling line.

The government may impose regulations on indication of product specifications, permitted volumes, bottle quality with regard to safety and so on. Also, there may be a governmental and public opinion on the use of non-returnable packages, which have to be considered. From a pure economical standpoint the choice between multi- or single trip usage depends on container costs, number of trips possible, transport distance, efficiency of collecting empties and relative handling costs on the filling lines (washing!)

Considerations on proper use of energy and raw materials, as well as on environmental pollution are becoming more and more important, however, and in some countries this has led to an increase in the use of returnables.

3. Relation between design and strength.

When speaking about the strength of a glass container, we have to define the kind of loading first. In practice there are four main groups to be considered:

- Thermal shock
- Vertical load
- Internal pressure
- Impact

All of these have certain implications on the design of the container, some even contradictory to each other, so that a compromis has to be found.

We will discuss some of the basic principles here, but before that we have to determine the factors that determine the strength of the material glass.

Glass is a brittle material, at room temperature there is no plastic deformation. This means that the mechanical strength is primarily determined by the surface condition.

A glass with a perfectly smooth, undamaged surface can reach strength levels of 7500 kg/cm^2 or more.

Even a visually undamaged surface, however, will contain small micro-cracks and this reduces the strength considerably. In normal use, a glass object will - on average - have a strength of 500 kg/cm^2 and heavily damaged glass (like returnable containers after several years) can fall down to say 300 kg/cm^2

All this refers to the tensile or bending strength. Compressive strengths are so high, that they need not be considered here.

The figures given here are mean values, especially for new glass the standard deviation can be 30% or more.

3.1 Effect of design on thermal shock resistance.

Thermal shocks occur in the washing machines, during pasteurization and during hot filling.

In a glass surface which is suddenly cooled to a lower temperature, transient tensile stresses will develop, depending on thermal expansion coefficient, wall thickness and temperature differences in the glass. Due to the low thermal conductivity, those stresses may remain for quite some time.

For a hollow soda-lime-glass cylinder the tensile stress at the surface σ_s is given by:

$$\sigma_s = 3{,}42 . \Delta T \sqrt{t},$$

if ΔT is the temperature difference in °C, t the wall thickness in mm and σ_s the tensile stress in kg /cm^2. For an abraded surface σ_s should not exceed 300 kg /cm^2. For t = 4 mm this means a maximum temperature shock of 44°C.

Especially vulnerable for thermal shock breakage is the heel of a bottle, the place where body and base meet. Thermal breakage often shows as a circular crack, separating the base from the body. A gentle "insweep" (curvature going from body to base) is essential to avoid thermal breakage.

Of course, thin walled containers will be less vulnerable than containers with thick walls.

3.2 Effect of design on vertical load resistance.

Vertical loads occur in capping machines and during storage, when trays are placed on top of each other. If maximum vertical load strength is required, all radii of vertical curvature must be as large as possible, which means in practice that square shoulders and too strong insweeps must be avoided. A container with a good shoulder design can have a vertical load strength as high as 5000 kg, a bottle with square shoulders not more than 250 kg. Normally a radius of vertical curvature of 50 mm will be adequate.

3.3 Effect of design on internal pressure resistance.

Internal pressure resistance, or bursting pressure, is especially important for containers for carbonated liquids, but it has also significance during pasteurisation or sterilisation treatments.

The pressure in the container will give rise to tensile stress in the wall, depending on wall thickness, diameter, glass distribution, out - of - roundness and, especially, shoulder design.

The thicker the wall, the higher the bursting pressure; however, this will lead to a low thermal shock resistance. So an optimum must be found. A small diameter also favours a high bursting pressure, but this will easily lead to tipping over.

Design in general has a strong effect on bursting pressure. In practice only cylindrical containers will be strong enough for carbonated drinks.

In some cases the shoulder design can help to increase bursting pressure. It has been found that - unless the profile is too smooth - there exists an area of lower tensile stresses directly under the shoulder, due to a "stiffening effect" of the shoulder, as compared to a simple cylinder.

It is possible to design the contact zone, where the containers will touch each other, exactly at this place, in this way diminishing the effect of abrasion on bursting pressure. There is, however, often also an area of higher tensile stresses, so that a careful positioning of the contact zone is required. Computer programs have been made for this purpose.

The base of the container should be thicker than the body, since here we have a relatively flat surface put under pressure, which is essentially weaker than a cylinder.

3.4 Effect of design on impact resistance

When a hard object hits a glass container, on several places tensile stresses will develop.

There will be high contact stresses in the (small) contact area, there will be bending stresses at the inside surface under the contact area and there will also be so called hinge stresses in a relatively large area on the outside surface, at some distance from the place of contact. Hinge stresses occur because the cylinder - like body deforms during impact.

breakage usually is due either to contact stresses or to hinge stresses. The bending stresses only lead to breakage in very thin-walled containers.

Contact stresses dominate in rigid walls with little flexuring possibilities. A thick wall, a small diameter and a square shoulder profile favour the development of contact stresses.

Hinge stresses develop strongly in containers that can deform elastically under impact. A thin wall, large diameter and a large vertical curvature of the shoulder favour hinge stresses.

The highest resistance to impact is found, when both breakage types are just as likely to occur. This optimum depends on wall thickness as well as shoulder design. A good shoulder design can give more than 25% increase in impact resistance, compared to a straight cylinder.

When the container is hit at the lower area of the body, approaching the base, the situation becomes different in this respect, that the wall will always be rather rigid there because of the thick base. If the body remains straight down to the base, so that bottles can hit each other at the heel, large cracks may develop (so called "butterflies"), extending from the impact place into the base. Therefore, the insweep of the body should begin at some distance (10-15 mm) from the base, to avoid this phenomenon.

4. Conclusions

In this paper we have tried to give a survey of technical design aspects of glass containers. Much more could be said about it, but time is limited.

In conclusion we might say that, although certain rules exist for bottle design, there is still some freedom left to satisfy the demands of the commercial department.

It must be kept in mind, however, that a technically less favourable design will always have to be compensated by a higher glass weight, and this is only possible to a certain extend.

A N N E X VIII

PROPERTIES OF GLASS CONTAINERS AND WAYS TO IMPROVE THEM

1. INTRODUCTION

The title of this paper suggests that there is an urgent need to improve the properties of glass containers. Of course, there is always and everywhere room for improvements, but in the 2000 years glass has been used for packaging, the material has proved to be excellently suited for this purpose.

Good properties are for instance:

- The container does not deform plastically, so it can be reused and reclosed, if a suitable closure is used.
- The material is transparent, which offers the possibility of a good display of the product.
- The material is chemically very stable, especially in acid environment, which makes it very suitable for food packaging
- The material is not permeable for gasses, so that packages of CO_2 - containing liquids do not loose pressure, if sealed properly.
- Glass is easy to clean and sterilise
- The raw materials for glass are abundantly available
- Glass can be recycled.

Negative points, when compared to other packaging materials are the relatively high weight to volume ratio and - of course - the fact that glass can break.

We will discuss primarily those negative aspects and see what can be done about it, but also we will give some attention to other properties to see how an optimum use can be made of them.

2. USE OF RAW MATERIALS, ENERGY SAVING AND RECYCLING

Glass is made from sand, soda and limestone mainly, with 1 or 2% of Al_2O_3 and MgO and very small amounts of colourants, if required.

The availability of raw materials in general creates no problems. A greater source of worry is the increasing energy price.

To make a bottle of 500 g about 6 megajoules energy is required, including melting and forming.

Exploration and manufacturing of the raw materials takes about 2Mj extra (75% of this is used for soda manufacturing). This 2Mj is won, if recycled containers are used instead of raw materials.

In reality even more will be won, since melting broken glass is much easier than melting raw material and also, the heat, required for the endothermic chemical reactions during melting will not be needed.

Of course, collecting empty bottles, cleaning and further preparation of the cullet also takes energy, but it is far less than what is won.

In some European countries large metal containers are placed on central points in every town and a lot of propaganda is used to convince people they should put their empty, non-returnable bottles into those containers. The project has been quite successful, but nonetheless it is clear that a returnable bottle (which is reused as a bottle, and not as a raw material) is not only cheaper, but requires even less energy, in spite of the washing and transport.

The use of returnable containers has the additional advantage that streets, highways and picknick - places remain cleaner, since most people will prefer to get their deposit money back and not just throw the bottle away.

For those reasons, governments in some European countries, like Germany and Holland have introduced a "status quo", which means that no further increase in non-returnable packaging is allowed.

3. CHEMICAL PROPERTIES

For the great majority of uses, glass containers can safely be regarded as completely inert. From a fresh glass surface, placed in a neutral or acid liquid only a very small amount of alkali will be extracted (less than 1 $\mu g/cm^2$ at 20°C), the rate of extraction decreasing with the square root of time.

If necessary, a special surface treatment, known as "sulphating" may be given to the inside surface of the containers during manufacture. This reduces the extracted amount roughly by a factor 10. The method is widely used for storing transfusion liquids and other alkali - sensitive drugs.

If even this amount of alkali is considered too high, a special glass composition may be used, known as borosilicate glass. For ampoules this is common practice.

Glass is less stable in alkaline solutions with $pH > 9$, although the weight loss seldomly exceeds 0.1 mg/cm^2 per day at room temperature. Alkali-resistant glasses have been developed for special applications.

Glass should never be used to store fluor-containing liquids, since fluor strongly attacks the silicate structure. It is used for etching.

4. OPTICAL PROPERTIES

Flint (colourless) glass offers excellent transparency and provides optimal display possibilities for the product. In some cases, however, the use of flint glass is not advisable, since flint not only transmits visible light but also ultraviolet light, up from 300 nm.

For certain products (like beer) this can be harmful. Green glass gives some protection up to 330 nm, but in cases where this is not sufficient, amber glass may be used. Amber glass does not transmit light at wavelengths below 450 nm.

5. MECHANICAL PROPERTIES

Glass is a brittle material, so the strength depends primarily on the condition of the surface. Brand new bottles are relatively strong, since the surface does not contain scratches and cracks. Due to abrasion, the strength decreases with time.

As a consequence, returnable bottles should be stronger (heavier) than one-way bottles.

Due to a cushioning effect of the abraded layer, the rate of strength -decrease diminishes gradually until after several trips an equilibrium level has been reached. It is essential to take this effect of strength decrease into account in the design of a new container, especially when making decisions about glass weight.

Glass weight, or rather weight to volume ratio, is a most important factor concerning strength. Some 20 years ago, a ratio of 1 was not unusual. Since then, a lot of effort has been put into the lowering of this ratio without loosing strength.

Apart from design effects, which are discussed in a separate paper, a number of developments are worthwhile mentioning.

5.1 Glass distribution

One of the reasons for the high weight to volume ratios in the past, was the rather uneven distribution of the glass in the wall of the container. One could say, that a bottle is as weak as its thinnest spot. The development of better proces control during forming and especially the introduction of the so-called press-blow manufacturing method, made a much better glass disbribution possible, resulting in a lower glass weight, while preserving the strength of the container.

Unfortunately it is technically not yet possible to use the press-blow method for large-size narrow-mouth containers, but it is generally felt, that this is a matter of time only. In Japan, this problem was solved by the introduction of -for instance- a wide -mouth 1 l. coca cola bottle.

5.2 Chemical Strengthening

Glass breaks almost exclusively because of tensile surface stresses. By putting the surface layer under compression, the development of tensile stresses can be avoided to a certain extent. This is a way to increase the strength of a glass object.

In the case of glass containers a compressive surface layer can be produced by a chemical treatment, known as ion-exchange.

Basically, the glass structure consists of a three-dimentional network of SiO_4^{4-} - tetraeders, with $Ca^{2\pm}$ and $Na^{\pm}$ ions in the holes. By placing the glass in a molten potassium - containing salt, it is possible to replace the $Na^{\pm}$ ions in the surface layer by the larger $K^{\pm}$ ions. In this way a compressive stress is created.

The method originates from U.S.A. (Brockway Glass) and has been further developed by Yamamura Glass in Japan.

A container can be made 3-4 times stronger in this way and further weight reduction has become possible. Weight to volume ratios of 0.3 have been reported.

5.3 Surface protection

The most straight-forward way to avoid strength reduction with time is - of course - to prevent abrasion by some kind of surface protection.

Several methods have been proposed for this purpose, but only a few have proved to be satisfactory in the long run.

A method, widely used at present, is the so-called hot-end/cold-end treatment. At the hot-end of the annealing lehr a thin transparent layer (50-100 Å) of $Sn\ O_2$ or $Ti\ O_2$ is applied on the outside surface of the containers, followed by spraying a thin organic layer (e.g. polyethylene, glycole, stearate) at the cold-end of the lehr.

The metaloxide protects the pristine glass surface during annealing and serves further as a primer between the glass and the organic layer. The organic layer provides a dramatic increase in lubricity of the container surface. Slip angles decrease from 30° - 45° for uncoated glass down to no more than 8°. The scratch resistance increases by a factor 50 to 100.

Note, that there is no strength increase compared to newly formed containers. However, bottles sampled after the annealing lehr, have been found 20-30% stronger when coated.

The method is quite effective for non-returnable containers. For returnables, however, the function of the coating is limited to 3 or 4 trips at most, since the coating is gradually removed by successive washing and abrasion.

A more drastic approach was made by Owens - Illinois in the U.S.A. They developed the so-called plasti -shield bottle by shrinking a slightly foamed polystyrene or polyurethane cover around the body of the container, about 0.3 mm thick. The cover perfectly absorbs impacts (and noise) and rather light-weight containers could be produced, since the glass does not abrade. The system, however, is only suitable for non-returnables.

An entirely different approach was followed in Japan. Under governmental pressure a solution had to be found for the so-called exploding soft drink bottle problem.

A tough plastic coating was developed, strongly adhering to the glass surface, highly resistant to detergents and filling - line abrasion, so that it could be used for returnable containers.

The coating is about 0.25 mm thick, perfectly transparent and it keeps the fragments together in case of bottle breakage.

Soft drink bottles with this kind of coating are now in use not only in Japan, but also in Germany, Holland, France, Israel, Canada a.s.o., especially for large size containers (1,5 and 2 1).

After 25 trips the bottles still have their original strength, so a weight reduction was feasable.

The newest development in this field is the combination of chemical strengthening and plastic coating. Especially for packaging of carbonated liquids this seems an ideal way to create a strong lightweight glass package.

6. CONCLUSION

For centuries glass was the only packaging material available. Nowadays, the glass industry faces serious competition from other materials.

The glass industry is an old industry, with long traditions and at first it seemed reluctant to adjust to the changing situation.

Fortunately this attitude has changed and the innovations, discussed in this paper may serve to prove this point.

ANNEX IX

QUALITY CONTROL, STANDARDIZATION AND LEGISLATION OF GLASS CONTAINERS IN THE NETHERLANDS

1. INTRODUCTION

In recent years there has been a very significant increase in the quality of glass containers.

The main stimulances for this development were:

- demand of better quality by the bottling companies, due to higher filling speeds, more sophisticated sealing methods, etc.
- awareness that low quality products could be harmful for the public

In line with this development, there has been - and still is - a strong tendency for improved quality control, not only by the glass producers, but also by the bottlers, and for more detailed guidelines, specifications and standards. Also, governments have become active to produce regulations in areas of common interest, like public health, environmental protection, energy conservation, etc.

Although this development takes place in each country, t[illegible] .c, of course, differences to be found, due to the local situation.

In the European Economic Community, for instance, directives are being prepared, primarily to prevent hindering of trade between member states by harmonization of the requirements for marketing.

In this paper we will discuss the developments in this field and we will confine ourselves mainly to the situation in the European

Community and more specificially in the Netherlands.

We want to emphasize here, that the fact, that we discuss here the situation in the Netherlands mainly, does not imply that we consider this to be the ideal example for Mexico to follow. It may, however, be interesting to see the developments in a country, which is in an entirely different position, not only geo graphically but also economically and sociologically.

2. STANDARDIZATION

2.1 Industrial Standards

To be able to discuss quality, it is essential to agree on product specifications. This seems obvious, but it took a long time before this was accepted as a normal procedure between glass suppliers and their customers. The reason for this was that most bottling companies did not have facilities to measure the quality of their incoming ware and also had no idea of what quality could reasonably be asked from the glass manufacturer.

Of course they did not hesitate to complain when the glass containers created problems in their plant. These complaints were rather vague in most cases and it was often difficult to define the cause of the problems for customer as well as supplier .

In general the bottlers' wish could - with some exageration - be described as to receive bottles with ideal quality at no costs whereas they blamed the glass supplier to deliver bottles with poor quality at enormous costs.

To solve this unworkable situation, in Holland a committee was formed, consisting of members of the glass suppliers and the main bottling companies. The glass department of the institute of applied physics TNO was asked to play the role of "referee" between these parties. This is an institute that belongs to an independent organisation for applied research, called TNO. This committee has been able to set up specifications for glass containers and it is still active to keep these specifications up to date, in line with the increasing technical possibilities in glass manufacturing and increasing production speeds in the bottling plants.

The committee makes minimum quality specifications only and it is not impossible for a customer to get a better quality if required. In such cases TNO is often asked to assist in the drafting of the additional specifications and to perform the necessary laboratory tests.

It must be emphasized that in this whole development the government has played no role. It was based on agreement between suppliers and customers only.

In recent years there has been a increasing demand for industrial standards on a more international basis. The CETIE, a European organisation with representatives of both glass suppliers and users, is active in this field and has already created several industrial standards, especially with respect to container finishes for sealing.

This work, though progressing slowly, will certainly lead to guidelines on all quality aspects of glass containers. Compared to the Dutch specifications, described above, however, the CETIE specifications generally are somewhat less strict, due to the fact that here a compromis has to be found between the wishes of the industries in several countries.

Sometimes not only quality but also design is standardised. The design of the milk bottles in Holland, for instance, is the same in all bottling companies. In the beer industry agreement has been reached on the design of the 33 cl and the 40 cl returnable beer bottles on a European scale even.

2.2 Official Standards

There has never been a strong wish to create official national standards from the Standardisation Institute on glass containers in the Netherlands. There exists a national standard on the design and quality of milk bottles (copied from the industrial standard) and perhaps one or two more. International standards from CEN and ISO, however, are always adopted as national standards, including those on sampling and test methods for glass containers.

3. INPUT QUALITY CONTROL

Having agreed upon a set of specifications, the customer will want to know whether the ware he buys conforms to these specifications.

He can of course take the suppliers word for it, but in many countries it has become common practice to carry out some kind of input control.

Simple visual and dimensional checks can easily be performed by the bottling company. Measurement of strength, wall thickness, stresses, etc. require more sophisticated equipment and more skill of the workers.

In Holland it has been found more practical, economically and technically, to have these tests performed in a specially equipped, independent laboratory, i.e. the glass department of the Institute of Applied Physics TNO, shortly TPD.

The procedure is as follows:

- TPD carries out input quality control on behalf of bottling companies
- Tests are made on all aspects of the specification, normally including :

  visual defects(critical, major and minor)
  capacity and weight
  dimensions
  wall thickness
  thermal shock resistance
  internal pressure resistance
  vertical load resistance
  residual stresses
  coating thickness

  In some cases the first three tests are carried out by the bottling company itself.
- Samples are taken before or after delivery to the bottling company as specified.
- TPD advises the bottling company about rejection or acception of the lot. The decision remains with the company
- If the lot is rejected, the lot remains under the supervision of TPD. Destruction of the lot takes place in presence of TPD
- The supplier can reoffer the lot for inspection, for instance after sorting out the defective units.

The experiences with this type of centralised input control can be excellent, provided good planning exists. In Holland the time, needed for sampling, testing and reporting has been reduced to no more than one or one and a half day, depending on the place of sampling.

The mean quality level in the container industry in Holland has undoubtedly increased since the introduction of this system, because it was a stimulance for the suppliers to improve their quality system.

On the other hand, the suppliers appreciate the fact that in case of problems they can discuss these with people who know what is and what is not possible in glass manufacturing. The feed back of the results of the input control to the supplier can be of great value to the supplier. Often TPD can make suggestions to the supplier about the cause of the problems.

In some cases it is not the bottling company but the glass manufacturer who asks TPD to perform this type of quality control. In that case the product is sold with a TPD certificate, stating that the containers are up to a certain standard. This often happens when government regulations exist on the quality of the containers, as is the case in Holland for soft drink bottles.

4. LEGISLATION

4.1 Governmental regulations

Most governmental regulations in the Netherlands on glass containers are simply a consequence of being a member of the European Economic Community, since all EEC directives conclude with the sentence: " Member states shall put into force the laws, regulations and administrative provisions needed in order to comply with this directive within 18 months of its notification".

Especially in the field of consumer protection, however, the Dutch Government has been active to create national laws, not based on EEC directives.

For glass containers, this concerns especially the quality of soft drink bottles with regard to their strength. Rules have been made to minimise the explosion probability of soft drink bottles. These include a minimum wall thickness of 2 mm, upper limits for allowed carbonisation (related to the internal pressure resistance), maximum head space and a ban for all glass soft drink containers larger than 1 liter.

For plastic coated containers special regulations have been made.

In the field of environmental pollution the government has "strongly advised" industry not to introduce any new nonreturnable packages replacing returnables. The PET - bottle, for instance, was taken from the market shortly after its introduction for this reason.

4.2 EEC - directives

The Council of the European Communities has adopted several directives on glass containers.

These directives are prepared in committees, consisting of government representatives from all member states, who usually have direct contact with the industry involved in their countries.

Among the most important directives, published up to now in the field of packaging are those on the making-up by weight or volume of certain prepackaged products, including lists of permitted volumes.

The first directive on this subject was published in 1974 on prepackaged liquids (No. 75/106/EEC).

The first part of this directive fixes the tolerances permitted for the actual contents of the prepackage compared to the nominal volume.

Table 1 gives the data:

Table 1

Nominal volume of the contents V_n in millilitres				Tolerable negative error in % of V_n	in millilitres
from	5	to	50	9	-
from	50	to	100	-	4.5
from	100	to	200	4.5	-
from	200	to	300	-	9
from	300	to	500	3	-
from	500	to	1,000	-	15
from	1,000	to	10,000	1.5	-

Note that only a negative error has been fixed. The EEC has no objections if the bottler wants to give the consumer more than the nominal volume.

The second part of the directive describes methods for checking batches of prepackages. The checking is carried out by sampling and consists of two parts:

- a check on the actual volume of the contents of each prepackage in the sample
- another check concerning the average of the actual volumes of the contents of the prepackages in the sample

criteria for acceptance or rejection of batches are described in detail.

In order to make it easier for the bottlers to conform to these regulations, another directive has been adopted (75/107/EEC of 19 december, 1974) which fixes the maximum permissible errors (positive and negative) of the nominal capacities of glass containers as follows:

Table 2

Nominal capacity of glass containers V_n in millilitres to be used as measuring containers*	Maximum permissible errors as a % of V_n	in millilitres
from 50 to 100	-	3
from 100 to 200	3	-
from 200 to 300	-	6
from 300 to 500	2	-
from 500 to 1,000	-	10
from 1,000 to 5,000	1	-

* The bottler is allowed to use containers with higher tolerances, but by using "measuring containers" he has the advantage that filling to a certain predetermined level is sufficient guarantee for the government that he conforms to directive 75/106/EEC.

The third part of directive 75/106/EEC lists the permitted nominal volumes for all kinds of liquids. This list has been attached to this paper as Annex A.

In 1976 a directive was published relating to the making-up by weight or by volume of certain prepackaged products as an extension of the former directive, now including regulations on solids and semi-solids.

In general this directive is similar to the one of 1974, with one important exception: there is no list of permitted quantities here. It was tried to include such a list, but the problems were many, especially for products to be filled by weight.

The differences in specific weight between various products appeared to be so large, that to be able to pack for instance 100 g of product for almost each product a different container size had to be specified. It is clear, that the costs of such an operation would be enormous for industry.

It took 4 years, until in 1980 an agreement was reached on the permitted (in this case brimful, of course) capacities for glass and metal containers for products to be filled by weight. This list - in Dutch but with an unofficial Spanish translation of the relevant parts (the parts on dog food and washing powder have been omitted)-has been attached to this paper as Annex B It can be seen that the list is valid only for a limited range of products. It includes packages for fruits, vegetables, tomatoes and potatoes only.

Many products, like for instance jams, mayonaise, salad sauces, mustard, have not (yet?) been included.

It is also clear that the list of permitted quantities is rather long and that the main aim of the community to reduce as far as possible the number of volumes that are too close to others of the same product and which consequently are liable to mislead the consumer, has hardly been reached. But, as the council states in their introduction: "such a reduction can only be undertaken gradually".

It should be pointed out here, to avoid misunderstanding, that a EEC-directive is not the same as national legislation. In spite of the adoption of the EEC-directives described above, each country still has the right to allow, within its own borders, other capacities.* Each member state is obliged, however, to permit the importation of products in accordance with the directives from other member states and at the same time cannot expect other EEC-countries to accept its products, in case those products do not satisfy the requirements from the directives. The aim of EEC-directives is harmonization, not legislation.

The lists of permitted quantities, described above, for instance, have to our knowledge in none of the member states been adopted as a national law. It may be expected, however, that as a natural consequence of the existence of exportation problems for capacities outside the lists, on the long run a reduction of capacities will take place, because industry will tend to select capacities. mentioned in the lists.

On the contrary, the other parts of the two directives, discussed here, have been adopted as national laws in the member states, so that all bottlers in the EEC have equal obligations concerning the tolerances in filling level or weight.

5. IMPLEMENTATION OF GOVERNMENT REGULATIONS AND EEC-DIRECTIVES

The government in the Netherlands has its own organisation to check whether products that fall under a certain law regarding their quality conform to this law.

* An exception to this rule forms the note in the list of permitted nominal volumes of liquids (see Annex 5A).

This organisation has several inspection bureaus in the country, taking samples of all kinds of products - mainly food - in shops, warehouses and factories.

The organisation not only checks the quality of the food, but also whether the actual contents of a package conforms to the nominal contents, following the methods, described in the EEC-directives. Of course, also imported ware from other member states can be checked in this way.

The inspection bureaus also check if soft drink bottles in Holland conform to the national law, described above. In this case, however, the bottler has to provide information to the government once a year concerning the internal pressure resistance of the glass containers he uses. TPD has been appointed by the government as the institute to perform the tests necessary to obtain this information.

In practice this means that TPD takes a random sample of 500 containers in each soft drink plant (used bottles from the available stock) once a year to check the internal pressure resistance.

The bottler sends the report of this test to the government and depending on the results of the test the bottler obtains permission (for one year) from the government to fill with a certain carbonation level. The inspection bureaus of the government of course check whether the bottlers do not produce with a higher carbonation level than allowed for that particular bottle type.

The tolerances of the capacity of glass containers offered as measuring containers according to directive 75/107/EEC (see table 2) are not checked by the inspection bureau, but by the Dutch Metrology Service.

6. CONCLUSIONS

In this paper we have tried to give a general survey of what has been done in the Netherlands in the field of quality control and legislation of glass containers.
We have not been able to cover the whole field completely. For instance, the activities of government and EEC, concerning conservation of energy, raw materials and environmental protection have not received the attention they deserve. They have, however, been included in other papers on this seminar.

All the efforts in recent years have undoubtedly led to a higher and more uniform quality level of glass containers and to more protection and safety for the consumers.

We do not want to suggest that the Dutch or EEC- solutions are perfect and certainly not that they form the example for Mexico to follow without careful considerations. Which decisions should be made in Mexico concerning glass containers is not for us to judge. Our stay in Mexico is certainly of too limited duration to evaluate all the aspects involved. We hope, however, that this paper has brought some new light on some matters, which are known to be highly controversial in this country at the moment. Also, we trust that the planned new activities of LANFI in the field of glass containers and the training programs in connection with this, will help Mexico to take the best decisions in this field.

LIST OF PERMITTED NOMINAL VOLUMES OF LIQUIDS, INCLUDED IN EEC-DIRECTIVE 75/106/EEC OF 19 DECEMBER 1974

Liquids	Nominal volume of contents in litres	
	I Finally permitted	II (*) Provisionally permitted
1. (a) Wine of fresh grapes; grape must with fermentation arrested by the addition of alcohol (CCT heading No ex 22.05 C) except for liqueur wines	0·10 — 0·25 — 0·35 0·375 — 0·50 — 0·70 0·75 — 1 — 1·5 2 — 5	0·20 — 0·36 — 0·475 0·60 — 0·68 — 0·72 0·95 — 1·75 — 1·88
(b) Other non-sparkling fermented beverages, for example, cider, perry and mead (CCT heading No 22.07 B II)	0·10 — 0·25 — 0·35 0·375 — 0·50 — 0·70 — 0·75 — 1 — 1·5 — 2 — 5	0·20 — 0·33 — 0·36 0·72
(c) Vermouths and other flavoured wines of fresh grapes (CCT heading No 22.06) liqueur wines (CCT heading No 22.05 C)	0·10 — 0·375 — 0·50 0·75 — 1 — 1·5	0·20 — 0·35 — 0·36 0·68 — 0·70 — 0·72
2. (a) Sparkling wines (CCT heading No 22.05 A+B)	0·10 — 0·125 — 0·20 0·375 — 0·75 — 1·5 3	0·57 — 0·77
(b) Other fermented sparkling drinks for example, cider, perry and mead (CCT heading No 22.07 B I)	0·10 — 0·125 — 0·20 0·375 — 0·75 — 1 1·5 — 3	0·57 — 0·77
3. Beer made from malt (CCT heading No 22.03):	0·25 — 0·33 — 0·50 0·75 — 1 — 2 — 3 4 — 5	0·18 (in cans only) 0·20 — 0·30 — 0·35 (in cans only) 0·45 — 0·66 — 3·8
— acid beers, gueuze	0·375	
4. Spirits and other spirituous beverages (CCT heading No 22.09)	0·05 — 0·10 — 0·20 0·35 — 0·375 — 0·50 0·70 — 0·75 — 1 1·5 — 2 — 2·5 3	0·25 — 0·36 — 0·60 0·72
5. Vinegar and substitutes for vinegar (CCT heading No 22.10)	0·25 — 0·50 — 0·75 1 — 2 — 5	0·35 — 0·7 — 1·5 2·5
6. Edible oils (CCT heading No 15.07 A I) (CCT heading No 15.07 D II)	0·10 — 0·25 — 0·50 1 — 2 — 3 — 5	0·375 — 0·625 — 0·75 1·5 — 2·5

Liquids	Nominal volume in litres	
	I Finally permitted	II (*) Provisionally permitted
7. Milk and milk based beverages sold by volume (CCT heading No 04.01) (excluding yoghourt and kephir, CCT heading No 22.02 B)	0·10 — 0·2 — 0·25 0·50 — 0·75 — 1 2 — 3 — 4	0·22 — 0·33 — 0·6
8. (a) Waters, including spa waters and aerated waters (CCT heading No 22.01)	all volumes below 0·20 — 0·20 — 0·25 0·33 — 0·50 — 0·70 0·75 — 1 — 1·5 2	0·35 — 0·45 — 0·47 0·90 — 0·94
(b) Lemonade, flavoured spa waters and flavoured aerated waters and other non-alcoholic beverages not including fruit and vegetable juices (CCT heading No 22.02 A)	all volumes below 0·20 — 0·20 — 0·25 0·33 — 0·50 — 0·70 0·75 — 1 — 1·5 2 — 3 — 4 5	0·35 — 0·45 — 0·47 0·60 — 0·90 — 0·94
9. Fruit juices and vegetable juices, whether or not containing added sugar, but unfermented and not containing spirit and non-concentrated fruit juices (CCT heading No 20.07)	all volumes below 0·125 — 0·125 — 0·20 0·25 — 0·33 — 0·50 0·70 — 0·75 — 1 1·5 — 2 — 3 4 — 5	0·18 — 0·35 (only in cans)

(*) As regards the prepackages whose nominal volumes are out in Column II, Article 5 shall, in respect of countries which permitted free circulation of these prepackages on 31 December 1971, apply only till 31 December 1980, except for the prepackages specified under heading 8 (a) which shall apply up to 31 December 1985.

Note: The liquids mentioned in points 1 (a) and (b), 4, 8 (a) and (b) and 9 may be put up for sale in the Community only in prepackages having the nominal volume of the contents as shown in the above table and conforming to the relevant regulations or to the normal commercial practice in the Member State of origin of the liquid, whether packing is carried out in the Member State of origin or in another State.

LIST OF PERMITTED CAPACITIES OF GLASS AND METAL CONTAINERS, TO BE USED FOR CERTAIN PRODUCTS FILLED BY WEIGHT.

REEKSEN VAN DE TOELAATBARE CAPACITEITSWAARDEN VAN RECIPIENTEN

De normen EN 23,1, uitgave 2 (mei 1978) en EN 76, uitgave 1 (december 1978) zijn van toepassing met uitzondering van die gevallen waarin de produkten en de reeksen van capaciteiten volgens deze normen afwijken van die van deze bijlage.

1. CONSERVEN EN HALF-CONSERVEN IN METALEN BLIKKEN EN IN VERPAKKINGEN VAN GLAS: PLANTAARDIGE PRODUKTEN (VRUCHTEN, GROENTEN, TOMATEN, AARDAPPELEN, MET UITZONDERING VAN ASPERGES, SOEP, VRUCHTE- EN GROENTESAPPEN EN VRUCHTENECTARS) BESTEMD VOOR MENSELIJKE CONSUMPTIE

1.1. Metalen blikken en verpakkingen van glas (capaciteit in ml):

106 — 156 — 212 ([1]) — 228 ([1]) — 314 — 370 — 425 ([1]) — 446 ([1]) — 580 — 720 — 850 — 1 062 — 1 700 — 2 650 — 3 100 — 4 250 — 10 200

1.1.1. *Aanvullende lijst voor bekers:*

53 ([2]) — 125 ([2]) — 250 ([2])

1.2. Lijst van de voor speciale produkten toegestane capaciteiten (capaciteit in ml):

— *Truffels:* 26 — 53 — 71 — 106 — 212 — 425 — 720 — 850

— *Tomaten:*
pasta : 71 — 142 — 212 — 370 — 425 — 720 — 850 — 3 100 — 4 250
al dan niet gepeld: 236 — 370 — 425 — 720 — 850 — 2 650 — 3 100

— *Vruchtencocktails, vruchten op siroop:* 106 — 156 — 212 ([1]) — 228 ([1]) — 236 — 314 — 370 — 425 ([1]) — 446 ([1]) — 580 — 720 — 850 — 1 062 — 1 700 — 2 650 — 3 100 — 4 250 — 10 200

2. VOCHTHOUDEND HONDE- EN KATTEVOER (capaciteit in ml):

212 ([1]) — 228 ([1]) — 314 — 425 ([1]) — 446 ([1]) — 850 — 1 062 — 1 700 — 2 650

3. POEDERVORMIGE WAS- EN SCHOONMAAKMIDDELEN

De capaciteit van de voorverpakkingen moet overeenkomen met de hieronder aangegeven waarden:

Dozen nr.	*Volume in ml*
E 0,5	375
E 1	750
E 2	1 500
E 3	2 250
E 5	3 750
E 10	7 700
E 15	11 450
E 20	15 200
E 25	18 950
E 30	22 700
Vaten nr.	
E 5	3 950
E 10	7 700
E 15	11 450
E 20	15 200
E 25	18 950
E 30	22 700

([1]) [illegible]
([2]) [illegible]

Lista de capacidades autorizadas para recipientes.

1. Conservas y productos relacionados contenidos en recipientes de vidrio y metal: productos vegetales (frutas, verduras, jitomate y papas, no incluyen espárragos, sopas, jugos de frutas, jugos de verduras y néctares de frutas) para ser empleados para el consumo humano.

   1.1 Latas metálicas y recipientes de vidrio (capacidad en ml.)

   106 - 156 - 212 (*) - 228 (*) - 314 - 370 - 425 (*) - 446 (*) - 580
   720 - 850 -1062 - 1700 - 2650- 3100 -4250 - 10200 -

   1.1.1 Lista adicional para otros recipientes

   53 (**) - 125 (**) - 250 (**)

   1.2 Lista de capacidades autorizadas para productos especiales (capacidades en ml.)

   Trufas - 26 - 53 - 71 - 106 - 212 - 425 - 720 - 850

   Jitomates -

   - pasta - 71 - 142 - 212 - 370 - 425 - 720 - 850 - 3100 - 4250

   - jitomate con ó sin piel - 236 - 370 - 425 - 720 - 850 - 2650 - 3100

   Cocktail de frutas y jarabes con frutas - 106 - 156 - 212 (*)
   228 (*) - 236 - 314 - 370 - 425 (*) - 446 (*) - 580 - 720 -
   850 - 1062 - 1700 - 2650 - 3100 - 4250 - 10200

Notas: (*) Estas capacidades serán revisadas una vez más cinco años después de la aceptación de este documento.

(**) Capacidades autorizadas por un período de 10 años después de la fecha de aceptación de este documento.

ANNEX X

EQUIPMENT FOR QUALITY CONTROL AND TESTING OF GLASS CONTAINERS

A. MOST URGENT EQUIPMENT FOR QUALITY CONTROL

No.	Name	Function	Supplier	Price estimate in US $	Remarks
A1	Ramp Pressure tester	Bursting pressure test ASTM C147-76 (method B)	American Glass Research Inc. Postbox 149 Butler. Pa,16001 USA	9,745.00 (suppl. quote)	Order Complete with 10 blank inserts and following spare parts: -ionizer cartridge, ion exchanger. -Water filter -Cylinder -Water flow-valves -Water pressure-valves
A2	Manometer	Calibration of A1	Schaeffer en Budenberg B.V. Postbox 444 Alphen a/d Ryn Netherlands	500.00 (own guess)	Range 0-50 atm. accuracy better than 0,5 atm.
A3	Water softener	Required for water supply of A1.		1,500.00 (own guess)	Preferably automatic. capacity min. 10 l/hr.
A4	Vertical - Load tester	Vertical load test for containers	A.G.R. (see 1)	4,850.00 (suppl. quote)	Forms an accessory to A1.
A5	Top loading balance	Capacity of containers	Sartorius: Carl Zeiss de Mexico Av. Patriotismo 604. Mexico, D.F.	1,500.00 (own guess)	Digital display. Capacity 3 kg. Accuracy 0,1 g.
A6	Thermal shock tester	Thermal shock for containers: ASTM C 149-77	AGR (see 1) or own built	12,310.00 (suppl. quote) or 7,500.00 (own guess)	Lower price is for own built e.g. from drawings, available from ASTM, Washington

No.	Name	Function	Supplier	Price estimate in US $	Remarks
A7	Wall thick-ness gage	Measurement of wall thickness containers	AGR (see 1)	670,00 (suppl. quote)	Operates mechanically
A8.	Hot end coa-ting meter	Thickness of hot end coating on the body of con tainers	AGR (see 1)	4,675.00 (suppl. quote)	Complete with coupling liquid.
A9	Finish hot end coating meter	Thickness of hot end coating on the finish of containers.	AGR (see 1)	3,470.00 (suppl. quote)	Complete with coupling liquid.
A10.	Equipment for measuring and checking di-mensions.	Measurement of: -height -diameter -finish outside diameter -perpendicularity -bore -finish ondula-tion	L. Masini Av. Independencia 1300 Monterrey, or Mitutoyo México, D.F., or Boers en Co. Instr. en App. Fabr. V. Heekstr. 34 3125 BN Schiedam The Netherlands	8,500.00 (own guess)	Calibration with metal discs and bars, to be ordered at exact size. Calibers to make acc. to own design'
A11	Line simu-lator	Simulates abra-sion on filling lines	AGR (see 1)	1,985.00 (suppl. quote).	Complete to suit all container sizes.
A12	Tilt table	Measures slip an-gle of containers Lubricity test - for cold end coa ting.	AGR (see 1)	1,325.00 (suppl. quote).	
A13	Impact tester	Impact resistance of containers	AGR (see 1)	1,795.00 (suppl. quote).	
A14	Polariscope	Detection of coo-ling stresses in containers ASTM C148-77 (method A)	AGR (see 1)	1,425.00 (suppl. quote).	10 inch screen (model 110).

No.	Name	Function	Supplier	Price estimate in US $	Remarks
A15	Strain discs	Measurement of cooling stresses in containers (to be used in combination with A14) ASTM C148-77 (A)	AGR (see 1) or: BGIRA Sheffield Great Britain	2,205 00 (suppl. quote).	
A16	Diamond saw table	Cutting of glass containers	Available at LANFI	——	Suitable for large container sizes.

TOTAL PRICE ESTIMATE GROUP A: 51,645.00 (US $)

B. URGENT EQUIPMENT FOR QUALITY CONTROL

No.	Name	Function	Supplier	Price estimate in US $	Remarks
B1	Manual thickness probe	Wall thickness of containers	AGR (see A1)	3,065.00 (suppl. quote)	Operates on dielectric constant. Quick method.
B2	Polarization microscope	Detection of stresses and inhomogeneities in glass (containers)	Leitz (or eq.)	10,000.00 (own guess)	Suitable for use with B3. Exchangeable objective
B3	Berek compensator	Exact measurement of stress in glass	Leitz (or eq.)	2,000.00 (own guess)	To be used with B2
B4	Monochlore benzene	To match refractive index of container glass	Supplier of Chemicals	500.00 (own guess)	Required for B2. 2 l. is sufficient
B5	Torque meter	Measurement of torque, required to open container	Anchor-Hocking Corp. Lancaster Ohio, USA.	2,000.00 (own guess)	
B6	Scratch tester	Quality of cold end coating on containers	Ball Brothers USA	2,500.00 (own guess).	
B7	Finish Projector	Control of container finish dimensions	Fowler Tools and instruments. Auburndale 02166 Mass. USA	7,000.00 (own guess)	
B8	Glass grinding and polishing table	Preparation of samples for microscope, etc.	Buehler Ltd. 2120 Greenwood Street Evanston, Illinois, USA.	12,500.00	Incl. felt and grinding and polishing pastes.

TOTAL PRICE ESTIMATE FOR GROUP B: 39,565.00 (US$).

C. EQUIPMENT, REQUIRED FOR CHEMICAL ANALYSIS AND PHYSICAL TESTING OF GLASS.

No.	Name	Function	Supplier	Price estimate in US $	Remarks
C1	Spectrophoto meter	Optical transmission of glass	Available at LANFI	—	Range 300-1000 nm
C2	Set of Standard glasses for optical transmission	Calibration of C1	Institut National de Verre 10, Boulevard De Fontaine B-6000 Charleroi Belgium	2,000.00 (own guess)	
C3	Abbe refracto meter	Measurement of refractive --- index		2,000.00 (own guess)	Suitable for glass (solids)
C4	Liquids for matching refr. index	Quick comparison refractive index of glass, according to ASTM -- F 218-68		1,000.00 (own guess)	For description see ASTM F 128-68
C5	Multi-tube density comparator	Determination of glass density by sink-float method ASTM C 729-75	AGR (see A1)	1,005.00 (suppl. quote)	Including density solutions
C6	Dilatometer	Determination of thermal expansion coefficient	E. Leitz (Canada) Ltd. Midland/Ontario Canada	25,000.00 (own guess)	Range 20°-1000°C.
C7	Bending -- strength tester	Strength of glass ASTM C 158-72	Netzsch Geratebau Selb-Bayern Werkstrasse 19 W. Germany	8,000.00 (own guess)	
C8	Autoclave (121 °C)	Alkali extraction of glass ASTM C 225-73	Available at LANFI	—	Size suitable for - glass containers

No.	Name	Function	Supplier	Price estimate in US $	Remarks
C9	Atomic Absorption Equipment	Chemical Analysis of Na_2O, K_2O --- (emission mode) BaO, CaO, Al_2O_3 (absorption mode) ASTM C 169-75	Available at LANFI	———	
C10	Standard set of glass compositions	Reference for C 9	Nat. Bureau of Standards. Washington, D.C. USA	3,000.00 (own guess)	
C11	Sieve set with mechanical shaker	Preparation of powdered glass samples for alkali extraction (C8) ASTM C 225-73 (point 14.4)	W.S. Tyler Co. Mentor Ohio 44060 USA	4,000.00 (own guess)	
C12	Steel mortar and pestle	Preparation of powdered samples (C8 and C9)		1,000.00 (own guess)	See for description ASTM C225-73 and C 169-75, par. 13)
C13	Agate mortar and pestle	Preparation of - powdered samples (C8 and C9)		2,000.00 (own guess)	Like C12
C14	Jar mill	Glass crushing	Norton Co Akron Ohio 44309 USA	3,000.00 (own guess)	With steel and porcelain balls.
C15	Platinum disc with cover lid	Chemical analysis of glass and raw materials ASTM C 169-75		3,000.00 (own guess)	Capacity 100 ml
C16	Reagents for wet chemical analysis	Analysis of glass and raw materials		4,000.00 (own guess)	For details see ASTM C 169-75 and C 146-72

No.	Name	Function	Supplier	Price estimate in US $	Remarks
C17	Viscosimeters	Determination of annealing and softening point of glass (2 types)		15,000.00	Fiber elongation method, described in ASTM C 336-71 and C 338-73.
C18	Standard set for viscosity measurements	Reference set for C17	Nat. Bureau of Standards. Washington, D.C.	2,500.00	ASTM C 336-71 (Appendix)
C19	Multi-point temp-recorder with thermo-couples	General use		6,000.00	

TOTAL PRICE ESTIMATE FOR GROUP C: 82,505.00 (US $).

ANNEX XI

LIST OF BOOKS ON GLASS AND GLASS PACKAGING

1. "Packaging in Glass" B.E. Moody, 1977 (2nd Edition).
   Publ. Hutchinson, London.

2. "Handbook of Glass Manufacturë",F.V. Tooley, 1974, --
   (2 volumes). Publ. Books for Industry, New York.

3. "The Glass Primer ". H.H. Holscher, 1972.
   Publ. Books for Industry, New York.

4. "Properties of Glass" H. Rawson, 1981.
   Publ. Elsevier, Amsterdam.

5. "The Physical Properties of Glass". D.G. Holloway, and -
   D.A. Tawney, 1973.
   Publ. Springer Verlag, New York.
   (Wykeham science series No. 24).

6. "Emailleirung", Dietzel 1981.
   Publ. Springer Verlag.

7. "Glas, Natur and Eigenschaften " H. Scholze, 1980.
   Publ. Springer Verlag.

8. "Glastechnischce Fabrikationsfehler" Jebsen-Marwedel,
   2nd or 3rd Ed. Springer Verlag.

9. "Le verre dans les industries Alimentaires" P. Cardon.
Publ. Compagnie Française d'Editions, Paris, 1974.

ANNEX XII

INFORMATION ON TRAINING COURSES

A. Basic training on glass, with emphasis on glass containers.

Prof. Rawson.
University of Sheffield
Department of Glass Technology
Western Bank S 10 2 TN Sheffield
Great Britain.

10 weeks course on glass manufacturing and properties, especially containers.
From October till December each year.
Costs for overseas students £ 1, 300.-
Subscription should be made in June the latest, since this course is always overbooked.

This course can be extended to 9 months course, meaning that the first 10 weeks are combined with the short course and after that it continuos till June.

Cost for the 9 months course £ 3,600.00 for overseas students.

Leaflets and further information may be obtained from Prof. Rawson.
Price reduction might be possible on request.

B. Courses on special topics

American Glass Research organizes 3 courses on glass containers. 3 1/2 days each.

1. Basic course, mainly fracture diagnosis . Cost US$ 415.00
2. Trade course. Cost US $ 520.00
3. Engeneering course, mainly design aspects. Cost US $ 560.00

More information to be obtained from:

American Glass Research Inc.
P.O. Box 149
Butler, Pensylvania 16001
USA.
tel. (412) 2874779.

Officially the course is only open for members of the Glass Container Manufacturers Institute.

However, exceptions are possible for research institutes.

For this, one has to contact:

Mr. G. Titelbaum
Glass Container Manufacturers Institute
330 Madison Avenue
New York, 10017
New York, USA.