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(54) Improvements in or relating to the packaging of liquids.

(57) Container for a pressurised liquid, comprising an outer box, an inner flexible impermeable bag for containing the liquid, a tap for withdrawal of liquid from the bag, and a film sleeve of elastomeric material at least partially surrounding the bag, said elastomeric material having a tensile modulus at 50% elongation of 0.5 to 20 MPa, a stress relaxation such that at 200% and 50% test strains the decrease in stress per decade of log time is less than 50% and less than 25% respectively, a tension set of less than 20%, and a tensile elongation such that the sleeve is capable of expelling at least 50% of the contents of a filled bag. Especially useful for containing carbonated beverages e g beer, wine, cider, perry and soft drinks.

EP 0 207 708 A2

IMPROVEMENTS IN OR RELATING TO THE PACKAGING OF LIQUIDS

The present invention relates to improvements in the packaging of liquids, in particular pressurised liquids and more particularly to containers for carbonated beverages.

The bag-in-box techniques for packaging have been widely used for many years, particularly with regard to the packaging of still table wines. The package comprises an outer box, usually made of cardboard and fitted with a handle, and a substantially impermeable bag disposed within the box, the bag being filled with wine and fitted with a tap which projects through a suitable aperture in the outer box so that wine may be withdrawn from the container as and when required. The impermeable bag is usually of a multi-layer construction, for example an inner layer of polyethylene or an ethylene/vinyl acetate (EVA) copolymer and an outer layer comprising a triple laminate of polyethylene/metallised polyester/EVA or nylon/aluminium/polyolefin. The main advantage of a container of this type, in comparison to conventional bottles or the like, is that as wine is withdrawn the flexible impermeable bag collapses in compensation and no air enters the bag. This prevents the oxidation of the wine, which of course renders it undrinkable, and therefore the wine remains palatable for some time after the container has been opened. Other advantages of such containers are that they are readily stackable and transportable.

It has long been recognised that it would be advantageous if bag-in-box packaging could be used for carbonated beverages such as beer, lemonade and sparkling wine. The main problem which has to be overcome is that,as the carbonated beverage is withdrawn from the container, the carbonated beverage remaining in the container loses carbon dioxide into the headspace created. As the headspace becomes larger, the beverage loses more and more carbon dioxide and thus very quickly becomes flat. Furthermore, the impermeable bags in which the carbonated beverage is contained will also tend to bulge and this in turn tends to make the whole container unstable.

We have now developed a container for the packaging of pressurised liquids which is based, essentially, upon the bag-in-box principle.

Accordingly, the present invention provides a container for a pressurised liquid which comprises an outer box and an inner flexible impermeable bag for containing a liquid and having a tap incorporated therein so that liquid may be withdrawn from the container, the inner flexible bag being at least partially surrounded by a sleeve of a film of elastomeric material having the following properties:

a) a tensile modulus at 50% tensile elongation in the range of from 0.5 to 20 MPa; and

b) a stress relaxation such that at a test strain of 200% the material exhibits a decrease in stress per decade of log time of less than 50% and such that at a test strain of 50% the material exhibits a decrease in stress per decade of log time of less than 25%; and

c) a tension set of less than 20%; and

d) a tensile elongation such that when the sleeve is applied to a filled inner impermeable bag containing liquid it is capable of expelling at least 50% of the contents thereof.

TENSILE ELONGATION

The sleeve material used in the present invention is an elastomeric material which is capable of withstanding such a tensile elongation as defined by BS 903, Methods Of Testing Vulcanised Rubber, Part A2:1971 that, when it is employed as a sleeve around a beverage-filled inner impermeable bag, it is capable of applying sufficient stress to collapse the bag so as to expel at least 50% of the bag contents, and preferably at least 75% of the contents, and even more preferably at least 90% of the contents. Taking a spherical shape as being the shape requiring the lowest level of tensile elongation, it has been calculated that the sleeve material would be required to withstand a tensile elongation of at least 25% to expel at least 50% of the bag contents, a tensile elongation of at least about 60% to expel at least 75% of the bag contents, and a tensile elongation of at least about 120% to expel at least 90% of the bag contents.

Many elastomeric materials possess breaking elongations of at least 120%. However, it is important that the material should also satisfy the requirements of tensile modulus, tension set and stress relaxation as defined above.

Essential characteristics of the elastomeric sleeve are that it should be capable of minimising decarbonation of the liquid over a period of time prior to and during dispensing of the liquid from the container, normally defined by the shelf-life of the product, and it should assist the expulsion of the liquid from the impermeable bag to a high degree. In order to achieve these characteristics, the sleeve must be capable of applying a stress on the impermeable bag which is greater than that exerted by the carbon dioxide. It is obvious that this may be achieved with an elastomeric film which possesses a low tensile modulus by using such a film thickness that the required tensile stiffness is obtained. However, this may necessitate the use of what would appear to be an excessively thick sleeve. It is a feature of the present invention that by the judicious choice of elastomeric material, a film thickness may be selected which both satisfies the tensile stiffness requirements for the sleeve and is acceptable from the thickness/weight/cost point of view.

Elastomers for use in the sleeve may be non-crosslinked or crosslinked. It is possible that some vulcanized natural and synthetic rubbers, including thermoplastic rubbers, may be suitable for use as the elastomer but for thin sleeves it is found that preferred and advantageous elastomers are thermoplastic polyurethanes which may be non-crosslinked or crosslinked. It has been found that for a flexible bag containing 5 litres of beverage which is carbonated to a level of 1.3 volumes of carbon dioxide per volume of liquid, a sleeve which performs satisfactorily with respect to retention of carbonation and bag collapse may be fabricated from a thermoplastic polyurethane film in the range of from 0.15 to 0.50 mm thickness, whereas an equivalent sleeve manufactured from an elastomer with a lower modulus, e g a vulcanized nitrile rubber, requires a film thickness significantly greater than 0.50 mm, possibly as thick as 4.0 mm.

The various other properties of the film were determined as follows:

STRESS RELAXATION

The stress relaxation characteristics of the elastomeric films were determined by the following test method:-

Dumb-bell test-pieces conforming to BS 903, Part A2:1971:Type 2, were cut from the film material. A 25 mm reference length was marked on the narrow portion of the test-piece and the thickness and width of the test-piece were measured at 23±2°C in accordance with BS 903, Part A2:1971. The test-piece was placed in the grips of a suitable tensile testing machine (e g Instron model 1026) and extended to the required strain at a grip separation rate of 500±50 mm/minute. The test strain was calculated by the formula

$$100 \times \frac{ls - lo}{lo}$$

where:lo is the original unstrained reference length, and ls is the strained reference length.

The test-piece was held at the required strain for a minimum of 10 minutes at 23±2°C and the stress generated in the test-piece was measured at intervals of 0.1, 1 and 10 minutes from the attainment of the required strain.

A plot of stress (in MPa) against log time resulted in a substantially straight-line graph. A convenient method of analysing this type of data was to calculate the % decrease in stress per decade of log time. This was calculated from:

% decrease in stress per decade of log time =

$$\frac{S1 - S2}{S1} \times 100$$

where: S1 is the stress at the beginning of the decade interval, and S2 is the stress at the end of the same decade interval.

<u>For example</u>

Let S1 = stress at 1 minute = 7.15 MPa

and let S2 = stress at 10 minutes = 5.8 MPa

then % decrease per log interval =

$$\frac{7.15 - 5.8}{7.15} \times 100 = 18.9\%$$

When the test strain used is 200%, the material should exhibit a decrease in stress per decade of log time of less than 50%, preferably less than 30% and more preferably less than 20%.

When the test strain used is 50%, the materia1 should exhibit a decrease in stress per decade of log time of less than 25%, preferably less than 20% and more preferably less than 15%.

TENSILE MODULUS

The modulus at a given tensile elongation is as defined and determined by BS 903, Part A2:1971, Determination of Tensile Stress Strain.

The modulus at 50% tensile elongation, determined at 20±2°C, should lie between 0.5 and 20 MPa, preferably between 2.5 and 15 MPa and more preferably between 5 and 10 MPa.

Furthermore, the modulus at 100% tensile elongation, determined at 20±2°C, should lie between 1 and 25 MPa, preferably between 2 and 20 MPa and more preferably between 4 and 16 MPa.

Still further, the modulus at 200% tensile elongation determined at 20±2°C, should lie between 1.5 and 40 MPa, preferably between 7.5 and 25 MPa.

TENSION SET

Tension set was determined using the following test procedure. Dumb-bell test-pieces in accordance with Type 1 as described in BS 903, Part A2:1971 were cut from the elastomer film. A reference length was marked on the test-piece using a suitable method, the reference length being between 25 mm and 50 mm. The unstrained reference length was measured to the nearest 0.1 mm at 23±2°C. The test-piece was placed in the grips of a tensile testing machine (e g Instron 1026) and the test-piece was extended to the required strain at a grip separation rate of 200±20 mm/minute. The test strain was calculated by the formula

$$100 \times \frac{(ls - lo)}{lo}$$

where:

lo is the original unstrained reference length, and ls is the strained reference length.

For these tests a test strain of 100% was used.

The test-piece was held at the required strain for 15 +1,-0 minutes at 23±2°C after which period the strain was released at a rate of 200±20 mm/minute. The test-piece was removed from the grips of the test machine and laid free on a flat, smooth, wooden surface at 23±2°C. After a period of 10 +1,-0 minutes from the commencement of release of the applied strain, the reference length was measured to the nearest 0.1 mm. Tension set, as a percentage of the initial strain, was calculated by the following formula

tension set =

$$100 \times \frac{lr - lo}{ls - lo}$$

where:

lo is the original unstrained reference length, ls is the strained reference length, and lr is the reference length after recovery. The median value of three determinations was taken as the representative value of tension set for the material. The values for tension set, when determined by the above method, should be lower than 20%, preferably lower than 10% and more preferably lower than 5%.

The inner flexible impermeable bag must be capable of preventing the ingress of oxygen into the bag and of preventing the escape of carbon dioxide therefrom. The impermeable bag is thus generally of a multi-layer construction, for example having an inner layer of an ethylene/vinyl acetate (EVA) copolymer and an outer layer comprising a triple laminate of polyethylene/metallised polyester/EVA or nylon/aluminium/polyolefin. Bags known for use in bag-in-box containers for non-pressurised beverages such as wine may be employed in the present invention, provided of course that their strength is sufficient to withstand the pressure of the pressurised liquid.

The shape of the elastomeric sleeve may be, for example, substantially spherical, substantially tubular or in between these shapes. It may be substantially closed to substantially completely enclose the inner bag or it may be open at one or more positions, e g at one or both ends of a substantially tubular shape. For a tubular sleeve and a 4.5 litre bag, an example of suitable dimensions of the rectangular shape of the sleeve when flattened is about 12.5 cm × 25 cm.

When the film of elastomeric material is in the form of an open-ended sleeve, it may be desirable for the outer box to include a platform or strengthened portion at each end thereof in order to prevent the bag from bulging from each end of the sleeve. When the film of elastomeric material is in the form of a sleeve which is closed at one or both ends, it may be possible to dispense with one or both of the aforementioned platforms or strengthened portions, providing that the outer box is sufficiently strong to support the weight of the bag filled with pressurised liquid.

The inner bag is provided with a tap for the withdrawal of liquid therefrom and this tap will project through the sleeve of elastomeric film. The conventional way in which bag-in-box containers have been filled with liquids such as wine is by filling the inner bag with the required quantity of liquid, if necessary under pressure, through a port provided therein and thereafter inserting a tap of the appropriate dimensions into the port. This method might be suitable for filling bag-in-box containers with pressurised liquids if the liquid to be admitted to the bag can be chilled to a temperature at which it is still liquid but at which the escape of carbon dioxide from it is prevented or reduced to a very low level. For example, in the case of beer at a temperature of 0°C almost no carbon dioxide escapes from the liquid.

Alternatively to filling the bag through the tap port, the liquid may be admitted, if necessary under pressure, through a separate aperture in the bag, which aperture is sealed against escape of the contents of the bag after filling, for example by means of a one-way valve. A one-way valve also may be employed when filling the bag through the tap port, the valve being re-opened by insertion of the tap into the port.

The material of the inner bag usually is substantially inextensible and accordingly the overall dimensions of the bag in the flattened unfilled state should be significantly greater than the overall dimensions of the unstretched elastomeric sleeve. The sleeve may be applied to the inner bag in various ways. For example, the sleeve may be stretched mechanically and placed around the filled inner bag, or the sleeve may be stretched, frozen, placed around the filled inner bag and then allowed to warm up to restore its elastic properties. Alternatively a sheet of the elastomeric material may be folded to envelop the inner bag, if desired whilst the material is in a stretched state, and then joined along its edges to form the sleeve. A preferred method of application, however, is to place a sleeve or folded sheet of the elastomeric material around an inner bag which has been folded to reduce its shape dimensions, edge-seal the folded sheet (if employed), and thereafter fill the inner bag with the desired liquid, e g under pressure, so that the elastomeric material becomes stretched. This method may be adapted for continuous filling and assembly by the steps of providing a web of inner bags which are joined one to another along opposing edges thereof, folding the bags of the web to reduce their shape dimensions, assembling the folded web between two lengths of elastomeric film or between the two flaps of a longitudinally doubled elastomeric film, joining together the longitudinally adjacent film edges and, if desired, transversely joining together the opposing film surfaces between the bags, filling each bag with a predetermined quantity of the liquid, and thereafter separating the filled bag/sleeve assemblies. The joining or sealing of the sleeve or film suitably may be achieved by welding (e g heat-or ultrasonic-welding) or by means of an adhesive.

In the preferred method of producing a filled bag/sleeve assembly (continuous or not), as the bag is filled with the liquid, the contained volume of the bag increases and the outer surface of the bag presses and moves against the inner surface of the sleeve and causes the sleeve to stretch and expand. Preferably the friction between the outer surface of the bag and the inner surface of the sleeve should be minimised in order to minimise or avoid creasing of the bag and undesired irregular stretching of the sleeve. The friction may be minimised by means of a judiciously chosen folding pattern of the bag prior to filling, especially a folding pattern comprising both longitudinal and transverse folds (multiplanar folding), and/or by employment of friction-reducing means such as a low-friction interlayer between the bag and the sleeve, a low-friction coating of, for example, talc or silicone, on the outer surface of the bag and/or the inner surface of the sleeve, and/or by incorporation of a friction-reducing ingredient such as an anti-block agent or a lubricant in the elastomeric material of the sleeve.

The physical properties of the elastomeric material may be varied by known techniques, for example by uni-or multi-axial orientation (to produce anisotropy), by heat-treatment (to modify the crystalline structure and adjust the tension set), by incorporation of ingredients such as plasticizers and particulate (e g fibrous) reinforcing agents, by perforating the film, and/or by varying the film thickness. It may be desirable for the material to have different physical properties at different portions of the sleeve, for instance in order to inhibit non-uniform circumferential expansion of the sleeve which might tend to result from friction contact with the inner bag or from constraints in or by the container during filling of the bag, and/or in order to obtain a particular shape of the filled bag/sleeve assembly. These different physical properties may be achieved by use of the above-mentioned techniques. If desired, the sleeve may comprise two or more different elastomer films to achieve the required expanded product.

The film of elastomeric material may be manufactured by any of the methods which are well known in the art, for example by blown film extrusion, flat film extrusion, casting, calendering, injection blow moulding or extrusion blow moulding.

In a commercial form of the container, the tap may be confined within the outer box and the box may have a removable non-replaceable portion in the vicinity of the tap, for example a portion defined by perforations, so that this portion can be removed and the tap can be pulled through the resulting hole in the box for the first dispensing of the liquid. This ensures that the container is tamper-proof and spill-proof prior to the first dispensing of the liquid. The outer box generally will be provided with the appropriate printing descriptive of the contents thereof and usually will also have a carrying handle.

It will be understood that the containers of the present invention may be filled with any liquids although their most important application is as containers for carbonated beverages such as beer - (including lager), sparkling wine, cider, perry, lemonade and other carbonated soft drinks.

Claims

1. A container for a pressurised liquid which comprises an outer box and an inner flexible impermeable bag for containing a liquid and having a tap incorporated therein so that liquid may be withdrawn from the container, the inner flexible bag being at least partially surrounded by a sleeve of a film of elastomeric material having the following properties:

a) a tensile modulus at 50% tensile elongation in the range of from 0.5 to 20 MPa; and

b) a stress relaxation such that at a test strain of 200% the material exhibits a decrease in stress per decade of log time of less than 50% and such that at a test strain of 50% the material exhibits a decrease in stress per decade of log time of less than 25%; and

c) a tension set of less than 20%; and

d) a tensile elongation such that when the sleeve is applied to a filled inner impermeable bag containing liquid it is capable of expelling at least 50% of the contents thereof.

2. A container according to claim 1 wherein the film of elastomeric material has a tensile modulus at 100% tensile elongation in the range 1 to 25 MPa and a tensile modulus at 200% elongation in the range 1.5 to 40 MPa.

3. A container according to claim 1 or 2 wherein the film of elastomeric material has a tensile modulus at 50% tensile elongation in the range 2.5 to 15 MPa, a tensile modulus at 100% tensile elongation in the range 2 to 20 MPa, a tensile modulus at 200% tensile elongation in the range 1.5 to 40 MPa, a stress relaxation such that at 200% test strain the material exhibits a decrease in stress per decade of log time of less than 30% and at 50% test strain the material exhibits a decrease in stress per decade of log time of less than 20%, a tension set of less than 10%, and a tensile elongation such that when the sleeve is applied to a filled inner impermeable bag containing liquid it is capable of expelling at least 75% of the contents thereof.

4. A container according to claim 3 wherein the film of elastomeric material has a tensile modulus at 50% tensile elongation in the range 5 to 10 MPa, a tensile modulus at 100% tensile elongation in the range 4 to 16 MPa, a tensile modulus at 200% tensile elongation in the range 7.5 to 25 MPa, a stress relaxation such that at 200% test strain the material exhibits a decrease in stress per decade of log time of less than 20% and at 50% test strain the material exhibits a decrease in stress per decade of log time of less than 15%, a tension set of less than 5%, and a tensile elongation such that when the sleeve is applied to a filled inner impermeable bag containing liquid it is capable of expelling at least 75% of the contents thereof.

5. A container according to any of the preceding claims wherein the film of elastomeric material has a tensile elongation such that when the sleeve is applied to a filled inner impermeable bag containing liquid it is capable of expelling at least 90% of the contents thereof.

6. A container according to any of the preceding claims wherein the elastomeric material comprises a thermoplastic polyurethane.

7. A container according to any of the preceding claims wherein the film of elastomeric material has a thickness in the range 0.15 to 0.50 mm.

8. A container according to any of the preceding claims wherein the bag has an aperture for admission of pressurised liquid, said aperture having a one-way valve to seal the aperture against undesired escape of the contents of the bag after filling.

9. A container according to any of the preceding claims wherein the bag is of substantially inextensible material and the overall dimensions of the

bag in the flattened unfilled state are greater than the overall dimensions of the sleeve in its unstretched state.

10. A container according to claim 9 wherein friction-reducing means are present to reduce the friction between the outer surface of the bag and the inner surface of the sleeve when liquid is being admitted into the bag.

11. A container according to any of the preceding claims wherein the sleeve has different physical properties at different portions thereof.

12. A method for producing a container as defined in any of the preceding claims which comprises folding the unfilled bag to reduce its shape dimensions and applying the film of elastomeric material in a substantially unstretched state to surround the folded bag.

13. A method according to claim 12 wherein the bag is folded in a multiplanar fashion.