

A Flexible Tank and Method of Making such a Tank

5 The present invention relates to a flexible tank for bulk liquids and a method of making such a tank. In particular, the invention relates to a disposable flexible tank.

Flexible tanks, or flexitanks, are bulk containers that are used for storing and transporting fluids. These tanks can be constructed from a variety of rubber or thermoplastic materials and typically have capacities of up to 24,000 litres. In use flexitanks are used inside dry goods containers, thereby converting such containers into bulk liquid containers capable of carrying up to 21.5 tonnes of non-hazardous liquid product.

15 One known flexitank is made from a woven nylon or polyester fabric coated on both sides with synthetic rubber or thermoplastic material. The coating is done using a process called calendering. This is a re-usable tank, with a life span of, typically, five years. A disadvantage of this tank is that it requires re-cleaning after every use, which can cause contamination and environmental concerns. In addition, a large infra-structure is required to operate, handle, clean, service and return the tank. This means that there is a high capital cost associated with the running of the business. Furthermore, in practice, tanks of this type are subject to quality problems.

25 Due to the problems associated with re-usable tanks, there has been a trend in the market towards disposable or one-use flexitanks, typically made of thermoplastic (PVC). A disadvantage of these tanks is, however, that they are

subject to quality problems, with leakages being relatively common.

A further disadvantage of prior art flexitanks is that the manufacturing process makes these tanks susceptible to contamination. Where hygiene is of major concern this can cause problems.

An object of the present invention is to provide an improved flexitank, in particular an improved disposable flexitank.

Various aspects of the invention are defined in the independent claims. Some preferred features are defined in the dependent claims.

According to the present invention, there is provided a flexible tank that comprises a one piece body portion that is formed using blowing techniques.

An advantage of this is that it minimises the number of seams required to form the tank. This means in practice that the tank is less susceptible to leakages. Another advantage is that the interior of the tank is never touched by human hands nor is it exposed to the atmosphere or dirt or bacteria. This means that the tank can easily conform with the highest of hygiene standards.

Preferably, the one piece body portion is a seamless tube. The ends of the tube may be closed by, for example, welding.

Preferably, two one piece body portions are provided, one forming an inner liner and the other forming an outer liner.

The one piece body portion may be made of polyethylene, preferably a blend of resin and bonding agent. The ratio of the resin to bonding agent may be 75% to 25%. Preferably, the resin is Elite (Metallocene) 5100 resin (C6 Linear low density polyethylene (LLDPE)) made by Dow Chemicals. The bonding agent
5 may be a co-polymer, preferably ethylene butyl acrylate (EBA).

The or each body portion may comprise two or more layers, for example three or four. Preferably, the body portion is co-extruded. Preferably, the body portion comprises two layers. The two layers may be of different polyethylene,
10 one being, for example, a high density polyethylene, the other being a low density polyethylene. The body portion may be triple co-extruded, each co-extruded layer fulfilling a different function. The co-extruded layers may be Metallocene, EVA (ethylene vinyl acetate) and linear low density PE Octen (linear low density polyethylene).

15 According to another aspect of the present invention, there is provided a method of forming a flexible tank using blown film techniques to form a one-piece seamless body portion.

20 Preferably, the one-piece seamless body portion is a tube. The ends of the tube are preferably closed by, for example, welding.

Preferably, the step of blowing the tube comprises co-extruding at least two layers of material to form the body portion.

25 Preferably, two one piece body portions are provided, one being an inner liner and the other being an outer liner.

The one piece body portion may be made of material that comprises a blend of resin and bonding agent. Preferably, the ratio of the resin to bonding agent is 75% to 25%. Preferably, the resin is Elite (Metallocene) 5100 resin (C6 LLDPE) made by Dow Chemicals. The bonding agent may be a co-polymer, preferably EBA.

Various flexible tanks and methods for making such tanks in which the present invention is embodied will now be described by way of example only and with reference to the following drawings, of which:

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Figure 1 is a side view of a seamless tube of material for making a flexitank;

Figure 2 is a plan view of the tube of Figure 1, when laid flat, with its ends sealed, thereby to form an inner liner for a flexitank;

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Figure 3 is a side view of an outer tubular liner into which is inserted the inner liner of Figure 2;

Figure 4 is a section on the line III-III of Figure 3;

Figure 5 is a section through a seam for sealing the inner and outer liners of Figures 2 and 3;

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Figure 6 is a plan view of a flexitank that is sealed in the manner shown in Figure 5;

Figure 7 is an alternative seam arrangement for sealing inner and outer flexitank liners;

Figure 8 is a plan view of a flexitank that is sealed in the manner shown in Figure 7;

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Figure 9 is a side view of a flexitank that includes an in-transit hose

protector;

Figure 10(a) is a plan view of yet another flexitank;

Figure 10(b) is an expanded portion of a part of the flexitank of Figure 10(a);

5 Figure 10(c) is a section through a part of the flexitank of Figure 10(a);

Figure 11 is an example of a hose for connecting to the flexitank of Figure 10(a);

Figure 12 is a table that shows some physical characteristics of the flexitank of Figure 10(a), and

10 Figure 13 is a table that shows some physical characteristics of a barrier liner that can be added to the flexitank of Figure 10(a).

Figure 1 shows a seamless, open-ended, one piece tube of material 10. This seamless tube 10 is formed using a blown film technique, which involves
15 liquifying constituent materials, extruding them through a die and blowing them into a large bubble. In one example, the material liquified is a 75%:25% mix of Elite (Metallocene) 5100 resin (C6 LLDPE) made by Dow Chemicals and co-polymer EBA. In order to make a 23,000 litre capacity tank, the bubble formed is about 7m by 4m, typically 7.3m by 4.04m. The thickness of the
20 material of the bubble is typically 225 micrometers, but may be as much as 250 micrometers. The bubble is cut to form a seamless tube.

The seamless tube 10 is used as an inner liner 10 for a flexitank. Two holes are formed through the liner 10, as shown in Figure 2. Surrounding one hole is a
25 male flange 12; surrounding the other hole is a female flange 14. To seal the ends of the inner liner 10, seams 16 are formed, typically, 50mm from the edges of the tube 10. These seams 16 are welded.

Once the ends of the inner liner 10 are sealed, it is placed inside a similar, but larger outer liner 18, as shown in Figure 3. Formed through the outer liner 18 are two holes that correspond to holes 12 and 14 through the inner liner 10. A collar 20 is welded to the male flange 12 on the inner liner 10 and the outer liner 18, as shown in Figure 4. This collar 20 extends through the outer liner 18 and is adapted to receive the end of a hose for filling and emptying the tank. Connected to the female flange 14 is a pressure relief valve (not shown) for ensuring that the internal pressure of the tank does not exceed a pre-set level.

Once the inner and outer liners 10 and 18 respectively are correctly positioned, the ends of the outer liner 18 are sealed together, as shown in Figure 5. A tank formed in this way is illustrated in Figure 6, which shows a 7470mm by 3950mm sealed inner liner 10 inside a 7670mm by 4850mm sealed outer liner 18.

In an alternative arrangement, the ends of the inner liner 10 are not sealed separately prior to insertion into the outer liner 18, but instead the ends of the inner and outer liners 10 and 18 are sealed together at one position, as shown in Figure 7. A tank sealed in this way is shown in Figure 8. In this case, the width of the outer liner is identical to or very slightly larger than that of the inner liner, although it is longer.

Each of the inner and outer liners described above is fully sealed. This means that both primary and secondary containment are provided. This is advantageous because in the unlikely event of the inner liner being damaged, the outer liner can still fully contain any leakage.

In use a hose 22 is attached to the collar 20, as shown in Figure 9. To prevent the hose from falling around during transportation, in-transit hose protectors 24 are attached to the outer liner 18. These protectors have straps 26 that can extend around the hose. Each strap is welded to the outer liner at several points along its length. Buckles 28 are provided at one end, so that the straps 26 can be wound round the hose 22 to hold it against the tank and then secured to the buckles.

Early tests show that the following technical specifications can be achieved using the inner liner described above:

Thickness: 221 micrometers

MD Tensile strength: 29.5Mpa

TD Tensile strength: 36.4Mpa

MD Elmendorf Tear: 22.5 micrometers

TD Elmendorf Tear: >30g/micrometer

Low temperature flexibility: -25C

High temperature flexibility: 70C

Dart Impact: 1100g

Melt Point Index: 0.8

Hence, the flexitank is strong and relatively light. This is advantageous.

Whilst the flexitanks of Figure 1 to 9 have an inner liner 10 and an outer liner 18, the flexitank can be formed from a single liner having two layers, each of which performs different functions. This liner is made from a blown film, which is double co-extruded, i.e. formed by extruding two liquified components

at the same time. In this, the inner liner has two layers, one of which is a 225µm layer of the 75% to 25% mix of Elite (Metallocene) 5100 resin (C6 LLDPE) and EBA, the other of which is a 225µm polyethylene (PE) outer layer. This outer layer is provided to improve the strength of the tank and replaces the outer liner 18 of the previously described embodiments. As will be appreciated, in this case, the only seams that are needed, seal the ends of the single liner tube. Of course, the single liner flexitank could be made from more than two layers of PE. Alternatively or additionally, a polyamide barrier could be included to act as a barrier to oxygen, thereby protecting oxygen sensitive foods in the tank, such as wine or extra virgin olive oil.

In another example, the flexitank has five liners, four inner of which are joined together to define a 4-ply inner liner and one of which is an outer liner of woven polypropylene. An example of this is shown in Figures 10(a) and (b). Each of the four inner liners of this tank is formed using a triple co-extruded, blown film process. Each co-extruded layer comprises:

- 40% Metallocene
- 30% EVA (ethylene vinyl acetate)
- 30% linear low density PE Octen (linear low density polyethylene)
- 0.5% Lubricant,

where the percentages represent percentage by weight.

The materials of each inner liner are selected to provide optimised performance. For example, polyethylene is selected because it is strong, but relatively cheap and fully disposable. Metallocene has good transparency, is flexible, mechanically strong and provides a good seal, as well as being resistant to puncture. This is advantageous in a flexitank. As regards, EVA, this is a soft,

flexible plastic that is derived from low density polyethylene and vinyl acetate. It has good low temperature crack resistance and weatherability characteristics. This is advantageous, because it reduces flex cracking of the tank. In addition, EVA is also resistant to grease and oils.

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As mentioned above, each of the four inner liners is formed using blown film techniques. As before, each liner is formed by liquifying the constituent materials, extruding the materials and blowing them to form a bubble. In this case, however, each liner is triple co-extruded so that the bubble has three co-extruded layers. Typically, in the co-extrusion process, the Metallocene is the inner layer, the LLD-PE is middle layer and EVA forms the outer layer. The bubble that is blown is typically 125 μ m thick. Once formed, the bubble is then laid flat and cut into an open ended one piece tube, thereby to form a tube that has no longitudinal seam.

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In order to construct a flexitank, a first one-piece tube is made using the triple co-extrusion process. One end of the tube is sealed and one is left open. A second tube is then made to be substantially the same width as the first tube, but slightly longer. One end of this is sealed as before and the second tube is then stretched over the first tube. The same is then done for third and fourth tubes, each of these being the same width as the first tube, but slightly longer than the previous tube. It should be noted that because the first, second, third and fourth tubes are substantially the same width, there is a tight fit between each of these.

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Once the four inner tubes are inserted in each other, two holes are formed through them. A male flange 30 is fitted so as to surround one hole and a

female flange 32 is fitted so as to surround the other hole. Once these are in place, the open ends of the inner liners are sealed. This can be done either with a single weld to join all of the liners together or alternatively, each liner could be separately sealed. In the example of Figure 10(a), each liner is sealed progressively nearer its end and the seams for the second, third and fourth liners join not only the ends of that liner, but also skirt portions of the previous liners. Hence, the first liner is sealed; the end of the second liner and a skirt portion of the first liner are sealed together; the end of the third liner and skirt portions of the first and second liners are sealed together and so on, thereby to give, overall, a very strong and secure seal. This is shown in more detail in Figure 10(c). In any case, once these seams are welded, a 4-ply inner liner 34 is formed. It should be noted that this liner has a translucent, waxy feeling surface, with good moisture vapour barrier characteristics and above average chemical resistance.

Once the ends of the 4-ply inner liner 34 are sealed, it is placed inside a larger outer liner 36, which is made of woven polypropylene. This outer liner is added for strength and abrasion resistance. Woven polypropylene is made by weaving polypropylene tape in two directions. It is strong, recyclable and relatively inexpensive. The woven polypropylene is optionally coated with polyethylene. This coating adds strength and rigidity to the bag as well as making it dust tight and resistant to most oils and chemicals. A further advantage of using polyethylene is that it is compatible with the materials used for the 4-ply inner liner.

To make the outer woven liner, a large, single sheet of woven polypropylene is formed into a tube. Use of a single sheet of material limits the number of

seams needed. For a typical flexitank, as shown in Figure 10(a), the size of the sheet is 4m by 7.5m. Once the tube is formed, the 4-ply inner liner is inserted into it. Two holes are formed through the woven outer liner, each corresponding to those through the inner 4-ply liner. A collar is then welded to the male flange 30 on the inner liner and the outer liner, as shown in Figure 10(a). This collar, which is the same shown in Figure 4, extends through the outer liner as before, which collar is adapted to receive the end of a hose for filling and emptying the tank. An example of a suitable hose is shown in Figure 11. Connected to the female flange 32 is a pressure relief valve (not shown) for ensuring that the internal pressure of the tank does not exceed a pre-set level. Once the collar and pressure release valves are attached, the ends of the woven polypropylene outer liner are sealed, typically by sewing them together. In this way, a flexitank is formed having has a four one piece liners that are placed one inside the other to form a 4-ply inner liner, the 4-ply inner liner 34 being sealed inside an outer woven polypropylene liner 36. A section through a wall of the flexitank of Figure 10(a) is shown in Figure 10(c).

The flexitank of Figure 10 has many good physical characteristics as shown in Figure 12. In particular, it should be noted that the tank is very light weight, the woven polypropylene outer being only 220gsm and the total weight being only 790gsm. This is advantageous. The tank is also strong, flexible and has good elongation characteristics. In addition, the flexitank has very low oxygen and vapour permeability and so does not allow a large amount of water to permeate through its walls. This is advantageous when the tank is to be used to transport sensitive loads and in particular foodstuffs. Furthermore, it is wholly re-cyclable, which has clear environmental advantages. Using a multi-ply construction provides enhanced physical strength properties and improves

containment, durability and safety. In addition, the materials used to make the flexitank have stretch and energy absorption capacity, which enables the tank to resist failure under the harshest of conditions.

5 It should be noted that an additional inner liner could be provided in the flexitank of Figure 10, thereby to form a 5-ply inner liner. This fifth inner liner is a barrier liner that includes polyamide, which acts as a barrier to oxygen. This is useful to provide additional protection for flexitanks that are to be used to store food products. As for the other 4 inner liners, the additional polyamide
10 liner is formed using blown film, co-extrusion techniques. The preferred composition of the polyamide liner is 37µm of PE; 26µm of polyamide and 37µm of PE, in that order. A liner of this nature has barrier characteristics of 15cm³/m². 24h/l atm. This is advantageous. Further characteristics of the barrier liner are provided in Figure 12.

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It will be appreciated that the dimensions of the flexitank can be varied. In the example of Figure 2, the inner liner is 7470mm long and 3950mm wide, as measured when flat. Of course, tanks of different capacities could be made, although flexitanks are typically in the size range of 16,000 litres to 24,000
20 litres.

The inner liners of all of the flexitanks described above are formed using a blown film tube. This means that the tube has no panels, no welds and no seams. This is advantageous because it means that the flexitank is less prone to
25 leaking and so the quality is improved. In addition, the use of blowing techniques enables a co-extrusion process to be employed. This means that two or more layers of material, e.g. polyethylene, can be bonded together to perform

different functions. The materials used are ultra-high tensile, preferably multiply, ethylene co-polymers, which are resistant to most inorganic acids and alkalis at room temperature. In addition, they are insoluble in organic solvents below 60C. Furthermore, they have a good resistance to impact, over a wide
5 temperature range, typically –25C to 80C.

An advantage of the flexitank in which the invention is embodied is that it is cheap to produce. In addition, the manufacturing process involves a minimal amount of handling compared to current flexitank processing. In particular, by
10 using blown film techniques the interior of the flexitank is not exposed to human contact or the atmosphere, thereby making it extremely hygienic. This is useful when the tank is to be used for storing food products. Furthermore, the use of polyethylene enables the tank to provide good performance and area yield with a minimum of material consumption. This is good from an
15 ecological perspective. In addition, by using polyethylene, the tank can be recycled, making it more environmentally friendly. Hence the flexitank is fully disposable. This is advantageous because it avoids the need for re-cleaning of the tank and the inevitable health concerns associated with doing so.

20 A further advantage of the flexitanks in which the present invention is embodied is that they are less susceptible to leaking than known tanks and so provide improved performance. Tanks can be manufactured to exceed industry standards at a lower cost than existing technology. All of the liners described above can be made relatively cheaply to conform and comply with standards set
25 by the FDA, the BGA and the Japanese Canning Authority. Furthermore, they show good puncture resistance, impact strength and good tear strength. In addition, the flexitanks are wholly disposable, which has environmental

advantages.

A skilled person will appreciate that variations of the disclosed arrangements are possible without departing from the invention. Accordingly, the above
5 description of specific embodiments is made by way of example and not for the purposes of limitation. It will be clear to the skilled person that minor modifications can be made without significant changes to the operation described above.

Claims

1. A flexible tank, having a capacity in the range 16,000 litres to 24,000 litres,
the tank comprising a one piece body portion of polyethylene that is formed
5 using a blown film process to create a seamless tube of substantially
uniform lateral dimension closed at each end by a single lateral seam.
2. A flexible tank as claimed in claim 1, wherein two one piece body portions
are provided, one forming an inner liner and the other forming an outer
10 liner.
3. A flexible tank as claimed in any of claims 1 or 2, wherein the ends of the
tube are closed by welding.
- 15 4. A flexible tank as claimed in any one of the preceding claims, wherein the
one piece body portion is made of a polyethylene based resin and a bonding
agent.
5. A flexible tank as claimed in claim 4, wherein the ratio of the resin to
20 bonding agent is 75% to 25%.
6. A flexible tank as claimed in claim 4 or claim 5, wherein the resin is Elite
(Metallocene) 5100 resin (C6 Linear low density polyethylene (LLDPE)).
- 25 7. A flexible tank as claimed in claim 4, 5 or 6 wherein the bonding agent is a
co-polymer, preferably ethylene butyl acrylate (EBA).

8. A flexible tank as claimed in any preceding claim, wherein the or each one piece body portion comprises two or more materials, preferably in layers, for example three or four layers.
- 5 9. A flexible tank as claimed in claim 8, wherein a layer of the body portion comprises a material that is adapted to reduce flex cracking.
10. A flexible tank as claimed in claim 9, wherein the material that is adapted to reduce flex cracking comprises ethylene vinyl acetate.
- 10 11. A flexible tank as claimed in any preceding claim, wherein the body portion, or at least one of the body portions, comprises a barrier layer adapted to act as a barrier to oxygen and/or water vapour.
- 15 12. A flexible tank as claimed in claim 11, wherein the barrier layer comprises polyamide.
13. A flexible tank as claimed in claim 1, comprising a further outer liner.
- 20 14. A flexible tank as claimed in claim 2 or 13, wherein the outer liner is made of woven polypropylene.
15. A flexible tank as claimed in claim 14, wherein the woven polypropylene outer liner is coated on an inner surface with polyethylene.
- 25 16. A flexible tank as claimed in any preceding claim, wherein the material of the body portion has a thickness of 125µm.

- 17.A dry goods container converted for transporting bulk liquids by incorporating a flexible tank as claimed in any preceding claim.
- 5 18.A method of forming a flexible tank having a capacity in the range 16,000 to 24,000 litres, the method comprising forming a one piece body portion of flexible material of substantially uniform lateral dimension using a blown film process to create a tube closed at each end by a single lateral seam.
- 10 19.A method as claimed in claim 18, comprising sealing the ends of the tube at the seam by welding.
- 20.A method as claimed in any one of claims 18 or 19, wherein the step of blowing the body portion comprises co-extruding at least two layers of material to form the body portion.
- 15 21.A method as claimed in any one of claims 18 to 20, comprising forming a plurality of one piece body portions and fitting the body portions inside each other.
- 20 22.A method as claimed in any one of claims 18 to 21, wherein the one piece body portion is made of material that comprises a blend of resin and a bonding agent.
- 25 23.A method as claimed in claim 22, wherein the ratio of the resin to bonding agent is 75% to 25%.

24. A method as claimed in claim 22 or 23, wherein the resin is Elite (Metallocene) 5100 resin (C6 LLDPE).
- 5 25. A method as claimed in any one of claims 18 to 24, wherein the or each piece body portion comprises two or more materials, preferably in layers, for example three or four layers.
- 10 26. A method as claimed in claim 25, comprising forming a layer of the body portion using a material that is adapted to reduce flex cracking.
27. A method as claimed in claim 26, wherein the material that is adapted to reduce flex cracking comprises ethylene vinyl acetate.
- 15 28. A method as claimed in any of claims 18 to 27, wherein the flexible material is polyethylene.
- 20 29. A method as claimed in any one of claims 18 to 28, comprising forming the body portion with a barrier layer adapted to act as a barrier to oxygen and/or water vapour.
30. A method as claimed in claim 29, wherein the barrier layer comprises polyamide.
- 25 31. A method as claimed in any of claims 18 to 30, comprising co-extruding a plurality of materials for the body portion for the blown film process.

32. A method as claimed in claim 18, comprising forming an outer liner and locating the body portion in the outer liner.

5 33. A method as claimed in claim 32, wherein the outer liner is made of woven polypropylene.

34. A method as claimed in claim 33, including coating an inner surface of the woven polypropylene outer liner with polyethylene.

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35. A method as claimed in any of claims 18 to 34, comprising forming the body portion so that it has a thickness in the range of 125 μ m.

15 36. A method of converting a dry goods container for transporting bulk liquid, comprising arranging a flexible tank as claimed in any of the claims 1 to 17 inside the container.

37. A flexible tank substantially as described herein with reference to Figures 6, 8 and 10 of the accompanying drawings.

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38. A method of forming a flexible tank substantially as described hereinbefore with reference to the accompanying drawings.