CONTAINERS FOR VERY COLD OR VERY HOT LIQUIDS

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5 Sheets-Sheet 3

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CONTAINERS FOR VERY COLD OR VERY HOT LIQUIDS

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ABSTRACT OF THE DISCLOSURE

A container for liquefied gases comprised of extensible sheets wherein when restrained can be adapted to the construction of a tank which has a trapezoidal cross-section such as cargo tanks in the fore-and-aft ends of a ship. The extensible sheets have zones in which non-intersecting but meeting corrugations bound an enclosed area and extend beyond such area to meet corresponding corrugations in an adjacent zone; to meet the required conditions for a trapezoidal tank, the enclosed areas near the common edge of two non-perpendicular sides of the tank are made rectangular rather than square, while the remaining enclosed areas are square.

This invention relates to containers and a method of making containers for the storage of liquids, especially very cold liquids such as liquefied natural gas.

In U.S. Patent No. 3,184,094 (French et al.), a novel container and a method of making same containers for liquefied gases are fully described. In that specification details are given of a tank which is a hexahedron. It has been found that difficulties are experienced in applying the invention of said application Ser. No. 285,279 to the construction of a tank which is not a hexahedron, for example a tank which has a trapezoidal cross-section such as cargo tanks used in the fore- and aft-ends of a cargo ship. This is mainly because the edges of the walls of the tank must cross the corrugations transversely, and must not pass through one of the small enclosed areas.

Unless special precautions are taken, this means that it would be impossible to construct a tank of any reasonable size without the edges passing through one or more of the small enclosed areas.

According to this invention such difficulties may be overcome by constructing a container having walls comprising extensible sheets, each sheet having a plurality of zones in which non-intersecting but meeting corrugations entirely bound an enclosed area, the corrugations extending beyond each enclosed area to the sides of each zone, and the zones being placed side by side and end to end so that each of the corrugations in each zone meets a corrugation in a contiguous zone, comprising arranging all the common edges of the extensible sheets cross all the corrugations transversely and do not pass through an enclosed area, and where the common edge of two contiguous sheets is not perpendicular to the transversely directed boundary lines of the zones in one of the sheets, making the enclosed areas in that sheet rectangular so that the corrugations in that sheet meet those of the contiguous sheet at the common edge, and making the zones in the remaining parts of the sheets substantially square and also making their enclosed areas substantially square and locating those enclosed areas in the centres of the zones.

As used in this specificaton, the term "extensible sheet" means a sheet which when fully restrained and subjected to low temperatures will not suffer any stress exceeding its elastic limit.

The extensible sheets are preferably of metal, and if the container is used for the storage of a liquefied gas, metals which do not become embrittled at low temperatures should be used e.g., stainless steel, aluminium or aluminium alloys.

The corrugations can have any desired profile, that is they can be simple folds, curved, polygonal, or V-shaped. The extensible sheet can be made by welding or otherwise joining together a plurality of corrugated sheets, the edges of the individual sheets being transverse to the corrugations. However, perhaps the simplest and in any case the preferred manner, is to weld together offset to one another, a plurality of large and small trays so that the upturned edges of adjacent trays welded together at their edges constitute the corrugations.

The ratio of a complete length of corrugation to that portion of the corrugation bounding the enclosed area may vary but convenient ratios are 5:1 or 4:1, i.e., when the angles are welded together it means that the lengths of the large and small trays are respectively 4:1 and 3:1.

Very often some of the walls of the container will be at right angles to one another. If this is so, it is preferable if the zones are arranged so that in at least one pair of adjacent walls at right angles to one another, the boundary lines of the zones in the sheets constituting the two walls are made parallel to and at right angles to the common edge. It is also preferable that this common edge be made coincident with the boundary lines of the neighbouring zones. In these walls at right angles to one another and in those portions of other walls away from these edges, the zones are substantially square shaped. In the centre of these zones there will be substantially square enclosed areas, their bounding corrugations being at an angle to the boundary lines of the zones.

Where the zones are substantially square shaped in order that the corrugations in one zone shall meet those in an adjacent zone it is necessary for the corrugations when extending to the sides of the zones, to bisect the sides of the zones. This means that when the ratio of a complete length of a corrugation to that portion of the corrugation bounding the enclosed area is 5:1 the angle of inclination of the corrugations to the sides of the zone is about 14°. When this ratio is 4:1 the angle increases to about 18°. Corresponding angles for other ratios can be readily calculated, and the angles increase as the ratio decreases.

Where any wall is oblique with respect to an adjacent wall, if the corrugations in one extensible sheet are to meet those in the adjacent sheets, then some of the enclosed areas must be made rectangular- and not square-shaped. Generally it is only necessary that sheets where the transversely directed boundary lines of the zones in that sheet are not at right angles to the common edge of the two sheets, should have rectangular enclosed areas. It is usually only necessary that in such sheets those enclosed areas near the common edge be rectangular. Of course, when one has made the enclosed areas rectangular and not square, the other larger areas bounding the enclosed areas and common to four contiguous zones will also be rectangular and not square shaped.

In practice making the enclosed areas in the zones near an oblique edge rectangular and not square shaped means that the sides of the rectangles are increased by regular amounts as one proceeds from one corner to the next corner along the oblique edge (for example increments in the ratio 1:3:5:7: . . . ) until the length of the longer side of the rectangle is about twice the length of its shorter side. During this progressive increase in the lengths of the rectangles, the enclosed areas move further away from the oblique edge because the boundaries of the zones are
not parallel to the oblique edge. When the stage is reached where the length of the longer side of the rectangle is about twice the length of its shorter side one starts again, with a rectangle the longer side of which is only just greater than its shorter side, and progressively increases the length of the longer side as one proceeds along the oblique edge. Also at this stage one starts progressively elongating enclosed areas in that series of zones which are one stage nearer the oblique edge.

To reduce the amount by which the corrugations have to change their direction when they meet at an oblique corner it is preferable if the walls of the container comprise two series of zones. The only difference will be that the ratio of the total length of a corrugation to that portion of the corrugation bounding an enclosed area will be different for each series. When the walls comprise two such series, the series having the smaller ratio i.e., the bigger angle of inclination of the corrugations to the side of the zone, should be used near the oblique edge of the tank. Suitable series are one having a ratio of total length of a corrugation to the length of a side of the enclosed area of 5:1 and the other a ratio of 4:1.

In order that the container is suitable for storage of very cold or very hot liquids, it must be mounted in a housing, which should preferably comprise thermal insulation. The centres of the enclosed areas and also the large enclosed areas should be pivoted mounted so that these areas are capable of undergoing angular rotary movement about their pivots in response to thermal expansions or contractions of the sheets.

The invention is now described with reference to the accompanying drawings in which:

FIGURE 1 shows a perspective view of a trapezoidal cargo tank of a cargo ship with tapered sides,

FIGURE 2 shows a plan view of the tank with the sides collapsed and laid out flat,

FIGURE 3 shows part of FIGURE 2 with the increments in the lengths of the rectangles shown,

FIGURE 4 is an enlarged view of the area around the corner BAC in FIGURE 3,

FIGURE 5 shows a perspective view of a trapezoidal cargo tank of a cargo ship with tapered sides and a trunk,

FIGURE 6 shows a plan view of part of the top wall and part of the sides laid out flat of the tank of FIGURE 5,

FIGURE 7 is a view of a typical zone of an extensible metal sheet.

Referring to FIGURE 1 the forward end 2 and the port side 3 with the tapered bilge portion 4 of the tank 1 constructed of a series of large and small trays welded together, are shown. The zones are indicated by broken lines and are all square in the forward end 2 and the port side 3 where the ratio of the total length of a corrugation to that portion of the corrugation bounding an enclosed area is 5:1. In the bilge portion 4, however, these zones are parallelograms. In order not to complicate matters the method of mounting the individual trays is not shown. The full lines indicate the boundaries of the trays and the upturned edges of the trays project into the cargo tank, so that only the flat back faces of the trays are visible.

Referring to FIGURE 2 it will be seen that as the transversely directed boundary lines 8 in the aft end 7, the bottom wall 9, and the forward end 2 of the tank are at right angles to the common edges 10 and 11, the zones and the enclosed areas, such as the zone 12 and the enclosed area 13 in the aft end, are all square.

However, in the bilge portion 4 and the bilge portion 6 of respectively the port side 3 and the starboard side 5 of the tank, because the transversely directed boundary lines 14 and 15 are not at right angles to the common edges 16, 17, 18 and 19, the enclosed areas in the bilge portions 4 and 6 near the common edges 16, 17, 18 and 19 are rectangular, such as those indicated by numerals 20 and 21.

Similarly considering other triangles it can be established that

\[ y = x \cos \alpha \]

(i)

Considering the similar triangles ARS and ATV

\[ \frac{y}{z_1} = \frac{y}{z_2} = \frac{3y}{\cos \beta} \]

(ii)

Therefore

\[ 3zy + yz_2 = 3zy + 3yz_2 \cos \beta \]

Thereore

\[ \frac{z_2}{z_1} = 3 \]

Considering the similar triangles ARS and AXY

\[ \frac{y}{z_1} = \frac{y}{z_2} = \frac{5y}{\cos \beta} \]

(iii)

Therefore

\[ 5xy + yz_2 = 5xy + 5yz_2 \cos \beta \]

Therefore

\[ \frac{z_2}{z_1} = 5 \]

and

\[ D_1E_1 = x \sin \alpha, \tan (\beta - \alpha) \]

and

\[ D_2E_1 = x \sin \alpha, \tan (\beta - \alpha) \]

\[ y = RA = D_1 - D_2 + E_1 \]

\[ = AD_1 - D_2E_1 + R \]

Therefore

\[ y = x \cos \alpha - x \sin \alpha, \tan (\beta - \alpha) + B \]

\[ = x[\cos \alpha - \sin \alpha, \tan (\beta - \alpha)] + z_1 \cos \alpha - \beta] \]

\[ = x \]
Therefore
\[ Z = y - \frac{\cos \alpha - \sin \alpha \cdot \tan (\beta - \alpha)}{\cos (\alpha - \beta)} \]  
(v)

Substituting for \( y \) from Equation 1 we have
\[ Z = \frac{y^2 + \cos \alpha + \sin \alpha \cdot \tan (\beta - \alpha)}{\cos (\alpha - \beta)} \]

Knowing therefore the length of the sides of the zones in the bottom of the tank, that is 2x, and the angles \( \alpha \) and \( \beta \) one can calculate the length \( Z_0 \) and hence the other lengths \( Z_n \) using Equation iv.

Referring to FIGURE 5 the tank constructed of a series of large and small trays welded together is viewed from the forward end 40 and the starboard side 41, and the tapered bilge portion 42 and the trunk 43 are also shown. As with FIGURE 1 the zones are indicated by broken lines and the full lines indicate the boundaries of the trays, the upturned edges of the trays projecting into the cargo tank.

It will be seen that that portion of the tank below the lines EF and FG is of similar construction to the tank shown in FIGURES 1 and 2.

In the present case, however, the ratio of the total length of a corrugation to that portion of the corrugation bounding an enclosed area is 4:1 and not 5:1. This small ratio is also used for the portion of the tank (including the trunk) above the lines AB and CD. For the middle portion of the tank, i.e., that portion below the lines AB and CD, but above the lines EF and FG, the enclosed areas are smaller and the ratio is the same as the tank shown in FIGURES 1 and 2, i.e., a ratio of 5:1. It will be seen that the corrugations do not meet one another linearly along the lines AB, CD, EF and FG.

Referring to FIG. 6 which shows a plan view of the top of the starboard side, it will be seen that the lengths of the longer sides of the rectangles 44, 45, 46, 47, and 48 increase progressively as one proceeds along the oblique edge HH. Rectangle 48 having one pair of sides about twice the length of the other sides, the enclosed area 49 is approximately square, but enclosed area 50 is rectangular in shape. Also it will be seen that the enclosed area 50 is in a zone one stage nearer to the edge HH than the series of zones in which enclosed areas 44, 45, 46, 47, 48 and 49 are to be found. Another point to be noted is that when one has reached the stage where the rectangle has one pair of sides about twice the length of the other pair of sides, e.g., rectangle 48, it is not possible to have a small enclosed area where two corrugations meet at right angles in the zone one stage nearer the oblique edge, e.g., zone 52. Instead these corrugations merely meet at a T-junction as shown at 51.

FIGURE 7 shows the physical construction of a typical zone, defined by broken lines 55, with the central small tray 56 joined to the adjacent larger trays such as 57 (only part of which lies within the zone) by corrugations 58 which can readily flex in a direction transverse to the length of the corrugation. Each zone is fastened to the wall of a fixed outer structure at a point such as 61. In the central area of a tray 56 or 57, the mounting being such that under thermal expansion or contraction the zone rotates slightly about point 61, thus taking up the strain, as explained more fully in said U.S. Application Ser. No. 285,279. Each corrugation 58 extends, of course, into an adjacent and similar zone, as indicated by the full lines 58 in FIGURE 1, to define the respective larger trays which surround the small trays 56. The trays and corrugations are preferably made of thin sheet metal joined by welding or in any other suitable fashion.

It will be apparent that the embodiments shown are only exemplary and that various modifications can be made in construction and arrangement within the scope of the invention as defined in the appended claims.

I claim:
1. A container for the storage of very cold liquids, said container having at least two adjacent sides which meet at an obtuse dihedral angle and a third side perpendicular to both of said two sides, each said side being constituted by an extensible sheet capable of absorbing stresses due to thermal expansion and contraction, (a) each extensible sheet having a plurality of zones, (b) each zone including linear corrugations in the sheet material, said corrugations meeting, but not crossing, so as to bound an enclosed area within the zone, (c) the corrugations extending beyond each enclosed area to the sides of each zone, (d) the zones being arranged edge-to-edge so that each of the corrugations in each zone meets and extends into a corrugation in a contiguous zone, (e) all the zones being so arranged that all the common edges of the extensible sheets of two adjacent sides of the container cross all the corrugations transversely without passing through an enclosed area, (f) the common edge of one of the said two adjacent sides and said third side being at an angle other than a right angle to the transversely directed boundary lines of the zones in one of the sheets, (g) the enclosed areas in such one sheet adjacent said common edge being elongated rectangular and so dimensioned that the corrugations in that sheet meet those of the contiguous sheet at the common edge, (h) the zones in the central area of the sheets being substantially square and their enclosed areas being substantially in the centers of the respective zones.
2. A container as claimed in claim 1 in which the ratio of the total length of a corrugation to that portion of the corrugation bounding an enclosed area is 5:1.
3. A container as claimed in claim 1 in which the walls of the container comprise two series of zones, the ratios of the total length of a corrugation to that portion of the corrugation bounding an enclosed area being different for each series, the series having the smaller ratio being positioned near the oblique edges of the container which are at an angle other than a right angle to the transversely directed boundary lines of the zones of the adjacent sheets.
4. A container as claimed in claim 1, the corrugations being formed by the upturned edges of a plurality of large and small trays, said edges being welded together to provide said corrugations, said trays being offset to one another so that their edges form the said corrugations.
5. A container as claimed in claim 4, in which some of the adjacent walls of the container which are at right angles to one another, have the boundary lines of the zones in the sheets constituting such walls parallel to and at right angles to the common edge of such adjacent walls.
6. A container as claimed in claim 5, in which the common edge is coincident with the boundary lines of the neighboring zones.
7. A container as claimed in claim 3 in which the ratios in the series are 5:1 and 4:1 respectively.

References Cited

UNITED STATES PATENTS
1,799,234 4/1931 Huff 220—9
2,020,630 11/1935 Anderson 220—63
3,184,094 5/1965 Fisch et al. 220—5
3,302,358 2/1967 Jackson 220—9

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