



TANK CONSTRUCTION OF 75 000 m³ CAPACITY WITH DOUBLE SHELL AND DOUBLE BOTTOM

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Steel tanks, ecology, design

ABSTRACT

A design for an oil tank of 75 000 m³ capacity has been discussed. The tank is an ecologically safe object with respect to its use of a double shell and a double bottom with a monitoring system of some possible leakages.

Other new solutions in relation to the ones currently in use have also been employed.

STRUCTURES OF THE OIL TANK

In 1999 the authors of the paper designed a tank of 75 000 m³ capacity for crude petroleum for the Institute of petroleum Transport in Kiev. Owing to the use of a double shell and double bottom the engineering structure has become ecologically safe. A vertical section of the tank under consideration, with a view of the bottom is shown in Fig.1, whereas Fig. 2 illustrates

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the shell structure and the floating roof division into air-tight sections. The distance between the external and the internal shell amounting to 6,0 m was taken into consideration at a strong request by the customer. A distance like this is not required by the Polish regulations. Also at the customer's request the design of the roof was of a double-deck type, since it is more rigid than the pontoon floating roof. However, due to its greater stiffness the weight of the roof is heavier. A double-deck floating roof weighs about 474 000 kg, while the weight of a pontoon-floating roof, designed alternatively is only 255 000 kg.

The tank shells were based on two independent annular reinforced concrete foundations. Due to a great distance between the shells it was useless to make one foundation taking into consideration that such a construction might settle non-uniformly in course of the tank's operational use. Each of the annular foundations has a width of 60 cm and is founded at a depth of 1.4 m. between both the annular foundations and in the mid-part of the bottom there is to be made a sand bed compacted by vibrations like a sub-crust required for road surface subgrade.

The two steel bottoms are separated by a 5mm thick steel mesh. The dimensions of the mesh are 25 x 25 mm. Within the space between the mesh there is produced negative pressure whose constant value indicates leakages in the bottoms.

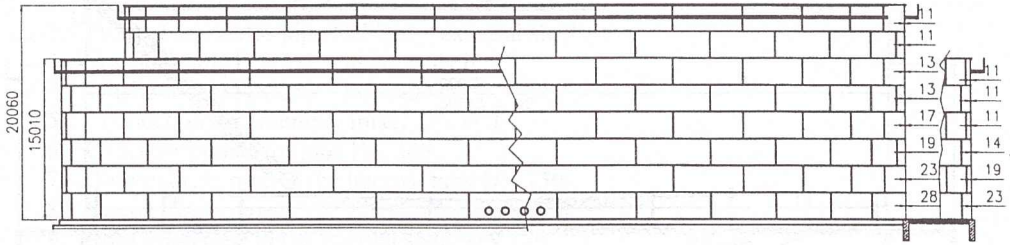
To facilitate the detection of some leakages the bottom has been divided into 7 sections each of which has its own leak tightness control. The authors of the project are aware of the fact that the negative pressure leak tightness control of the bottom may cause some objections, but this method has been used in the West for a long time, and so far no description of any other method verified by a long-term operational use has been found in literature.

The internal part of both the bottoms has been designed of 8 mm thick plates with anti-corrosive protection coat on the sand foundation side and on the inner side of the tank.

Since each of the seven bottom compartments should be made on one rainless day, in order to facilitate the assembly of the mid-part of both the bottoms it has been recommended to make use of the roll technology. The above requirement is connected with the necessity to avoid moisture during the assembly work, being propitious for corrosion in the space between both the bottoms. The peripheral plate strakes in the lower bottom beneath both the shells are made of 22 mm thick plates under the inner shell and 22 mm thick plates under the outer shell. The tank shells have been designed of 2500 mm high plates about 8 000 mm long to diminish the scope of the welding jobs.

VIEW OF TANK

TANK SECTION



LAY-OUT OF TECHNICAL ACCESSORIES ON THE TOP OF THE TANK SHELL AND ON THE FLOATING ROOF

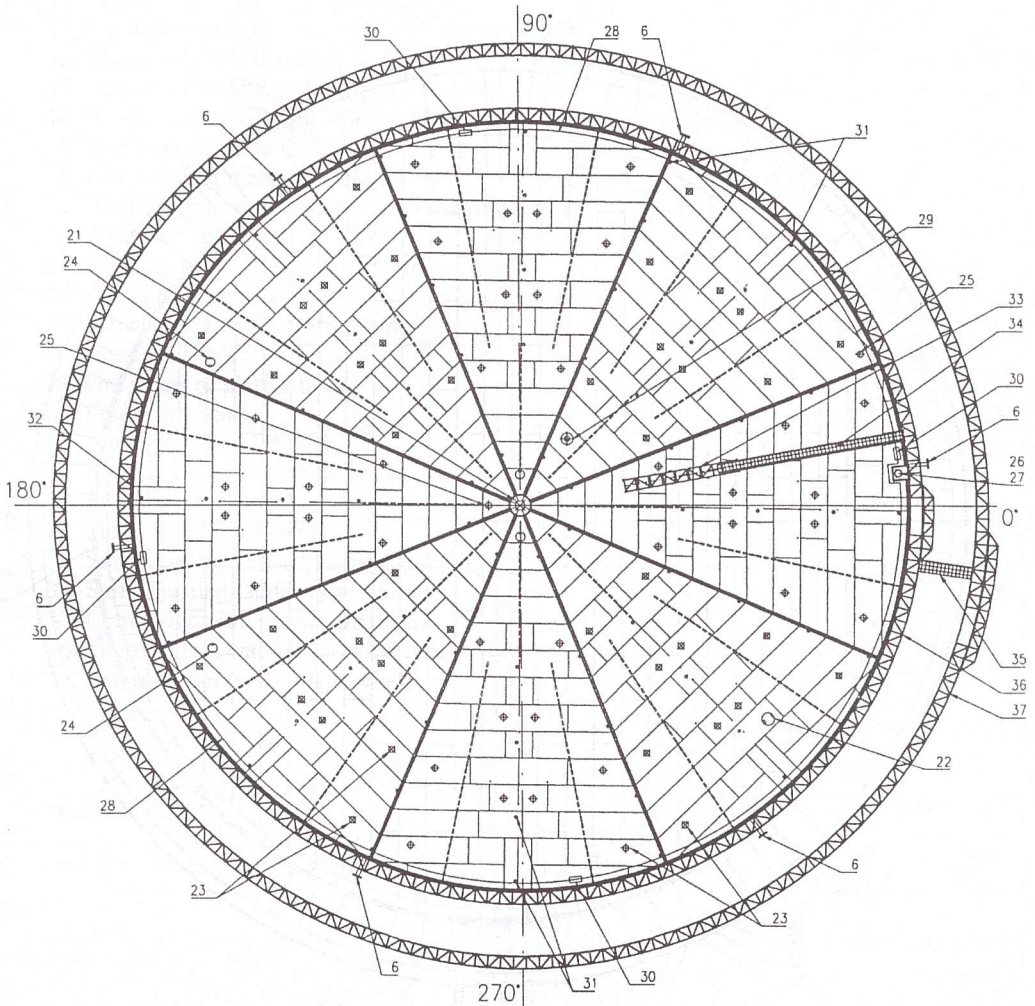
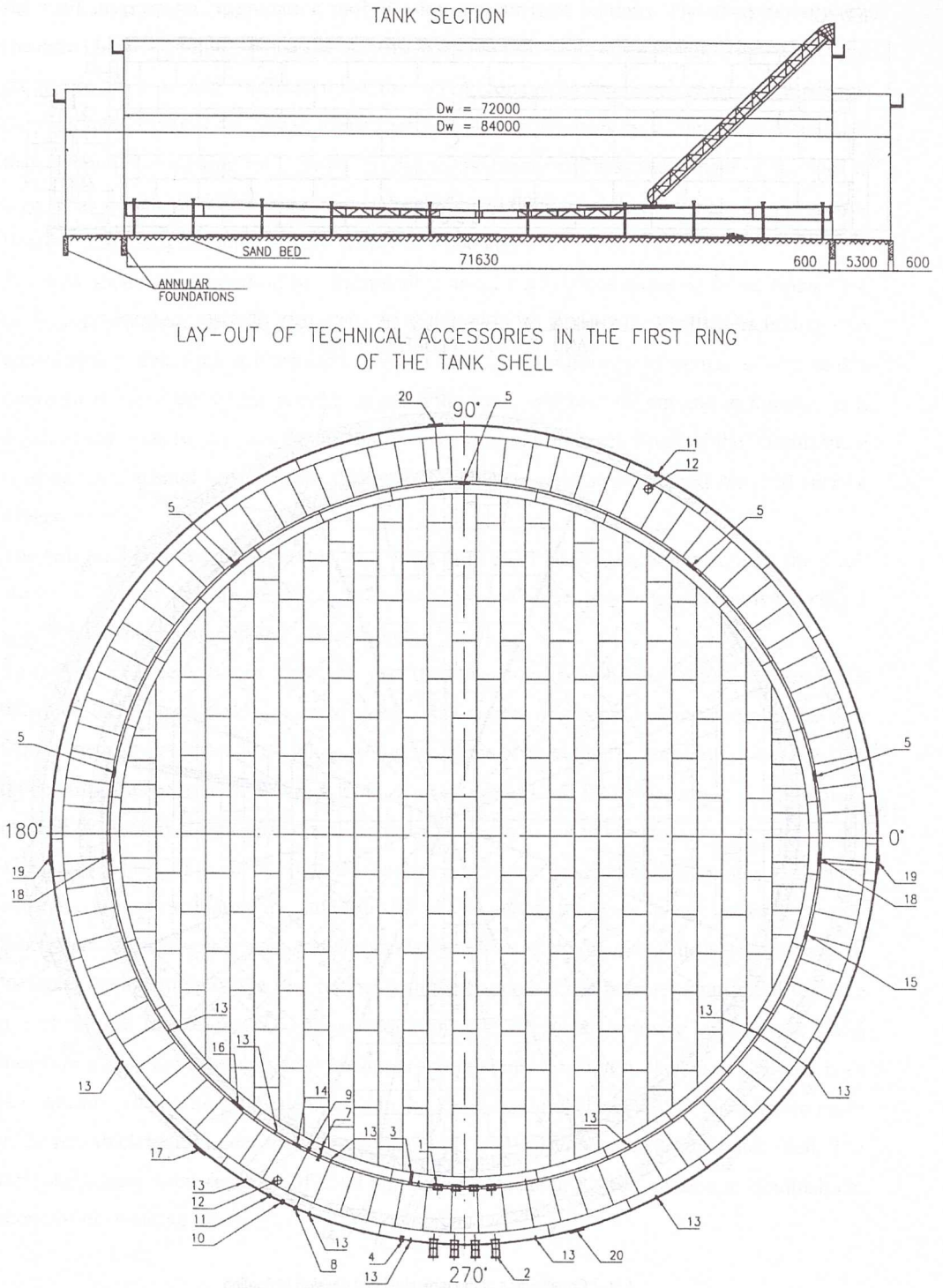


Fig. 2 Construction of the tank shell and division of floating roof into leak-tight compartments



Technical accessories of the tank (for Fig. 1, 2)

1. Product connector pipe DN 700 – internal shell
2. Product connector pipe DN 700 – external shell
3. Washout hole DN 250 – internal shell
4. Washout hole DN 250 – internal shell
5. Connection for assembly mixer DN 800
6. Overflow connector pipe DN 300
7. Bottom drain pipe of the internal tank DN 150
8. Bottom drain pipe of the external tank DN 150
9. Roof drain pipe in the internal shell DN 150
10. Roof drain pipe in the external shell DN 150
11. Removal of the water from the space between the shells – DN 200
12. Well DN – 800
13. Connector pipe of the bottom leak-tight control system
14. Manhole DN 600
15. Manhole DN 600
16. Manhole DN 600 x 900
17. Manhole DN 600 x 900
18. Washout manhole DN – 800 x 1250
19. Washout manhole DN 915 x 1220
20. Fast-opening manhole DN 900
21. Well for draining off water from the roof
22. Assembly manhole DN 1000
23. Opening to the bulkhead DN 500
24. Aeration opening DN 500
25. Connector pipe for taking samples
26. Roof guide bar
27. Guide bar of platform
28. Foam bulkhead
29. Aeration valve DN 800
30. Ladder over the foam bulkhead
31. Floating roof supports
32. Floating roof bumper
33. Surface of the self-adjusting ladder-type stairs
34. Self-adjusting ladder-type stairs
35. Communication service platform
36. Internal shell walkway – wind brace
37. External shell walkway – wind brace

In compliance with the order of the future user of the tank the product pipelines of 700 mm in diameter were welded to the shell at such a height that the pipeline axis was positioned 600 mm above the bottom.

Consequently some problems emerged, while carrying out a typical strengthening of the shell by welding some extra metal flanges. For this purpose in the pipeline areas of the shell, use was made of plates of much greater thicknesses, i.e. 60 mm. Whereas at other places of the periphery the lower plate strake of the inner shell was 28 mm thick, and the outer one was 23 mm in thickness.

Both the shell tops were capped with wind girders located at a height of 1.134 m below the upper edge of the shell (Fig.3).

The supporting structure of the wind girders consisted of circular trussed beams of 1200 m in width. The flanges of the trussed beams were made of T-shaped HEB 160 sections, while the supporting columns of double T-beams of dimensions 80x80x9 mm.

The wind girders are covered with galvanized grating landing of "Mostostal" type. In the project of the tank under consideration there is a departure from the traditional wind girder made in form of a horizontal plate structure. Such a wind girder has never been perfectly flat and therefore the rainwater accumulates in the local concavities in the walkway near all connections with the shell causing its corrosion above the walkway (Fig.4). It is worthy of noting another change in the construction of the wind girder in comparison with the traditional solutions. The change is connected with certain differences between Polish and Ukrainian fire-fighting regulations. According to Ukrainian regulations it is necessary to sprinkle water over the tank beginning with the top part not like in the Polish code, exclusively below the wind girder.

To satisfy the Ukrainian requirements it was not possible to weld the trussed frame flange of the wind girder directly to the shell, but to place it apart at a distance of 80 mm from the shell. This was possible to be accomplished by use of spacer washers made of T-bars arranged around the periphery of the shell every 1145 mm. The outer shell stability made it necessary to apply an auxiliary indirect wind girder, which was installed on the third plate strake 11 mm in thickness (counting from the top).

The auxiliary wind girder was made of plates welded in an L-shape of dimensions 200x200x15 mm and placed on the outer side of the shell so as not to inhibit the flow of water being sprinkled over the shell in emergency situations.

The lengths of the inner and outer shell plates have been so designed as to position the vertical welds within the same cross-sections, which is significant in view of the arrangement of the accessories, e.g. pipelines which cannot be welded at welds. The tank shells are designed for four types of steel (Table 1) aimed by reducing the plate thicknesses to diminish both the shell weight and the range of the welding works.

Table 1 . Construction of tank shells

INTERNAL SHELL					
Number of peripheral strake (counting from the shell bottom)	Plate thickness	STEEL CHARACTERISTIC			
		Type	Variety of workability*)	Yield point	Standard calculation strength
	mm			R _c (MPa)	f _d (MPa)
1	28	18G2AV	R	430	360
2	23	15G2ANNb	R	380	315
3	19	15G2ANNb	R	380	315
4	17	18G2A	D	345	295
5	13	18G2A	D	355	305
6	13	St3W	C	235	215
7	11	St3W	C	235	215
8	11	St3W	C	235	215
EXTERNAL SHELL					
1	23	18G2AV	R	430	360
2	19	15G2ANNb	R	380	315
3	14	18G2A	D	355	305
4	11	18G2A	D	355	305
5	11	St3W	C	235	215
6	11	St3W	C	235	215
*)Steel impact test for respective variations of workability values is made for the following temperatures: C 0 ⁰ C D -20 ⁰ C R -40 ⁰ C					

One of the elements of the communication system on the tank ensuring access to the floating roof from the ground level is the walkway connecting both the shells. The walkway has been so designed as not to create a rigid link between the shells, and so it is fixed to the internal shell and based on the external shell in a flexible way. Thus, provision has been made for independent deformation of both the shells by heat from the sun, as well as for non-transference of load in case of damage to one shell.

Independent operation of both the shells must also be secured for the passages through which the pipelines run. To fulfil this condition, in the space between the shells, there are expansion pipe joints.

The solutions related to the floating roof accessories do not differ much from the traditional ones.

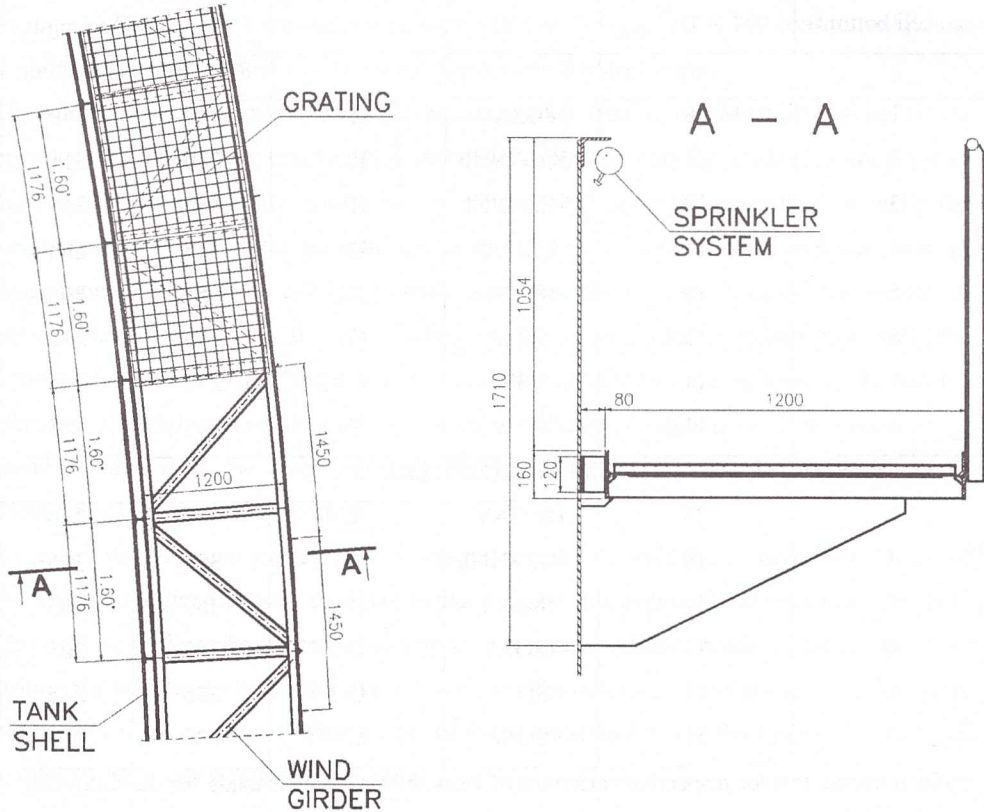


Fig.3 Construction of the wind girder



Fig. 4 Tank shell corrosion in the area near the plate wind girder