

METHODS OF ERECTION OF CYLINDRICAL STEEL TANKS

There are three general ways for erection of the Aboveground Steel Tanks (AST): by rolls; sheet by sheet and lifting method. These methods will be described briefly there.

a) rolls method – when the bottom and shell are made from rolled sheets, and roof (cone and spherical, self supported and supported) – made from shields. The advantages of this method are as follow:

- relatively quick method for erection, because the composite elements are biggest, made in special plants for metal constriction (i.e. ZMLK – “Septemvri”);
- input and output control of the production is easier and quicker, which make the terms shorter;
- increase the quality of the execution because bigger part of weld joints are made in a plant and welding of the elements is automated with special machines;
- the number of the workers needed for this operation is small.

A disadvantage of this method to some extent or limited appliance is that there is a maximum of the thickness of the sheets, which will be used for rolls making.

Maximum thickness can not exceed 14 mm for ordinary low carbon steel (S235) and 18 mm for low stainless steel with increased strength. The theoretical grounding for limits is made by B. V. Popovskiy. Therefore the tanks which have volume up to $V_1 \leq 20000 \text{m}^3$ can be made using the rolls method. In addition, for bigger volumes the dimension ***D*** and ***H*** of the tank must be took into account, because the facility of the KZU in NHK – Bourgas for instance can produce roll with height $H \leq 12,0$ m. Maximal height of the shell ***H*** made only by the rolls method can not exceed 18,0 m, which is due to the limit of the facility in ZMLK – “Septemvri”.

Other important disadvantages of the classical rolls method are:

- line placed crossing welds of vertical joints of the shell;
- whole uninterrupted vertical joint, made on the site, where are – inside picking;
- the use of the heavy and expensive facilities during the erection work;
- when the tanks are made according to the rolls method it is very difficult to achieve as good geometrical form as when the tanks which are made by sheet by sheet method.



Erection of AST with rolls method

b) sheet by sheet (classical) method. The whole sheet construction and section for bottom, shell and roof are cut and bend preliminary after the precise dimensions.

Advantages of the sheet by sheet method are:

- the expensive and complicated facilities such as when the rolls need, are not necessary for the sheet by sheet method;
- the erection works need relatively not so heavy facility and the facility could be applied for all the volumes of the tanks and the site;
- all vertical joints have length equal to the one course. So the crossing welds have been avoided which made the tank secure for exploitation;
- the shell and bottom shape is closer to the designed one;
- the tanks with every volumes and height can be made using the sheet by sheet method.

Disadvantages of the sheet by sheet method:

- relatively longer term for erection is needed;
- the number of the weld joints and the necessary control on the site is increased;
- more qualified workers are needed for this operation.



Erection of AST sheet by sheet

c) lifting method - it is kind of the sheet by sheet erection method. First must be done erection and welding of the bottom and the first (lower) course. The shell must be collected course by course on the insider part of the first course and only the vertical weld joints between sheets must be made. After the welding of the last course, the roof must be mounted and welded to the last one. The access for coming in the tank must be assured through one or two part of the roof cover plates by means of use of erecting stairs inside and outside.

The lifting began from the last course together with the roof. The jacking system type "Laterna" (10 – 15 t) must be used or hydraulic jacking system evenly positioned on the perimeter of the shell. The insider course must be lift up to the level in which the horizontal lap joint between upper course and the next one to be 60 mm of the entire perimeter.

It is necessary to be made double lap joint with minimum 2 layers per weld. First lap weld must be made outside in bottom position and then inside in ceiling position. The whole shell of the tank is executed as consecutive lifting and welding of the erecting horizontal joints. The correct lifting of the course must be controlled (the different courses must have the same axis) and every bending of the shell as a whole must be avoided.

This type of lifting method, with lap welds on horizontal joints, is not in application now. According all standards around the world every one shell joint have to be made as but, with full penetration and fusion.

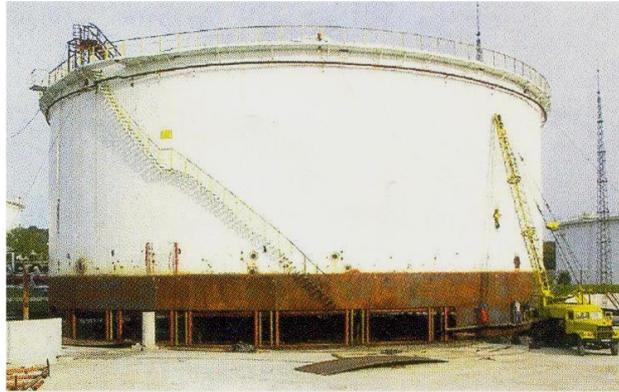
Increasing of capacity of the tank with lifting method and butt welds is often used in Bulgaria. The diameter D of the tank is unchanged but the highness of shell H grows up.

Technical sequence is as follow:

- lifting installation is fixed on project position;
- fillet welds between shell and bottom are removed;
- the shell and roof are jacked up more than new shell course;
- sheets in new shell course are mounted and fixed on project position under the lifted tank;
- vertical joints between steel sheets are performed;
- the tank lowers and horizontal butt joints between existing shell and new course is

performed;

- if it is necessary operations could be repeated - jacking up, mounting of new course, welding of vertical joints, welding of horizontal joint;
- welding of fillet welds between shell and bottom.



Increasing of capacity of AST by lifting method

The technology of the Swedish company BYGGING-UDDEMANN AB must be mentioned as one of the kinds of the lifting method. The succession of the operations is the following:

- upon the erected bottom must be constructed the upper shell course of the tank. The roof must be mounted and then jointed to the shell. The top angle must be made. The course and the connected to it roof must be lifted up to the level which allows to put the course below the lifted one through hydraulic jacking system. First the vertical joints must be executed and then horizontal joint between the two shell. All joints must be executed as butt weld with full penetration and fusion. The operation must be repeated till the completion of the construction of the whole shell. The last weld joint is between shell and bottom.

The advantages of the method are as follow:

- the welding operations are executed on the ground, which increases their quality and assures the security for the workers;
- easier access and easier control to the welded joints;
- scaffolding is not needed;
- when the roof of the tank is erected and the upper supporting ring is made, the constructors do not need any complementary stabilizing of the shell against the loss of stability in the radial direction caused by wind pressure during the erection work;
- big parts of the welding joints are executed under the erected roof.

d) **mixed method**. This is a method which is combination from sheet by sheet method and the rolls method, where the bottom is made by rolled sheets, the shell is made by sheet by sheet method and the roof is made by shields. This method combines the advantages of the rolls, sheet by sheet methods. This technology

allows the acceleration of the erection and the use of the relatively light mechanization.

e) **positive tendencies and solutions connected with erection of AST**

mounting of tank roofs as one part

The roofs will be mounted in accordance with accepted constructive solution – as shields or as separate radial and circular girders covered with plates in cone or dome roofs. Mounting of the roof element by element on the site when is relevant to the roofs where cover plates are not connected to supporting structures. Roofs mounted shield by shield on the site is used in roll method of erection. In the same time when the rolls of shell are being unfolded the mounting of the first, middle and closing roof shield is being executed. Both of the two so called classical methods for roof erection obviously require a lot of time and a lot of people are engaged. Many of mounting works must be done at big height.

In order to make mounting faster, to increase the quality of the joints and in order to make easier control there is a trend roofs to be mounted in their designed shape on the earth and after that to be put as whole element above the shell.



Mounting of dome roof on the shell as one assembly

mounting of AST with floating of self-supporting roof

This method can be applied in tanks with floating roofs and in tanks with self supporting cone or dome roofs. When the bottom and several courses in the shell are mounted the roof mounts inside the tank. When the roof is finished it must be stabilized to not turn or overturn. The water is poured gradually and the roof begins to float. The level of the water must remain such that allows the comfortable mounting operations and in same time to assure stability of the shell.

In tanks with fixed roofs and the shell is already mounted the top angle have to be mounted and then the roof must be welded to it.

The advantages of this method are as follow:

- the roof is used as floating work platform on wich the workers move. So the scaffolding is not needed;
- the static water load makes the soil tighter. Depending on geological conditions the process of soil settlement can become faster or can be completely finished till the moment of tank connection with outsider infrastructure of pipes. The risk of big deformation and turning in the nozzle zone is diminished;
- the time needed for hydrotest of the tank can be minimized because the time needed for filling AST also is diminished.

The following disadvantages can be noted:

- the water must be poured gradually inside the tank during the whole process of erection, not at once, which can cause a problem when the tank has big capacity;
- the lack of necessary quality of fresh water is possible and it makes this kind of consolidation impossible. Sea water accelerates metal corrosion and it is not advisable a contact between the steel and sea water for a long time;
- the shell of the tank which is not stabilized with rings behaves inappropriately during the earthquake when is full with water .



Erection of AST with floating of dome roof