TECHNICAL INSPECTION OF ABOVEGROUND STEEL TANKS

Lyubomir A. Zdravkov*

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Abstract: *Steel tanks for storage are responsible facilities which state deteriorates by the time of their exploitation. For reduction of risk of partial or full tank's destruction, it is necessary to perform periodical inspection of these tanks. The purpose of regular tank's inspection is to collect data about real condition of the reservoirs. This information contributes to take right decisions for repair and alteration of tanks in service.*

Key words: *Steel tank, inspection, repair, NDE, minimum thickness, inspection intervals*

1. Introduction

The vertical cylindrical steel tanks /further will be called only tanks/ used for oil and oil products storage belongs to dangerous facilities. During the long period of their use different processes take place in the tanks and those processes decrease the tank security and raise the destruction risk. The tanks accidents cause a material loss, environment impacts, risk for fires and human victims.

In order to decrease the risk for complete or partial tank destruction, it is necessary to inspect and to prepare estimates of the facilities. The purpose for technical inspection is to collect data for their actual condition. This information is needed for the following:

- possibility for further safe use of the facility;
- presence of the areas or elements which need replacement or repairing;
- mode and the terms for the next inspection and estimate of the remaining resource of the facility for safe use.

2. Requirements for tank preparing for inspection.

The stage of the preparing work for the inspection of its technical condition can be determined from the purpose and necessary volume of the work.

Before the beginning of inspection works the following actions must be done [6], [7]:

- the specialists who carry out the inspection must be provided with all technical and technological documentation of the tank.
- the preparing of the complex of works, assuring the safety of the carried out activities;
- to assure the access of the specialists which make the inspection and fault detection to all the areas determined to be inspected;
- the areas which are determined to be inspected must be cleaned and the elements which are an obstacle for the inspection works must be taken apart from tank;
- preparing of the shell, bottom and roof design where to mark the discovered defects and departure from project and norms.

3. Mode and regularity of the inspection work

The world practice shows that [7], [8] during the tank exploitation it is necessary to be carried out the following mode of inspection:

- outsider inspection during the exploitation;
- partial inspection;
- complete inspection.

3.1 Outside inspection

It is not necessary to stop the tank exploitation. The outside inspection must include the visual control of the surface of the tank for discovery of:

- leaks of the shell and/or the bottom;
- condition of the basic metal, the presence of the scratches, splits, cavities and another defects;

* Lyubomir Angelov Zdravkov, M. Sc., e-mail: L_Zdravkov@mail.orbitel.bg

- level of corrosion of tank elements;
- status of all defending varnish covering and appliances;
- damages of insulation;
- indications for settlement of foundation;
- local deformation, grooves, protuberances on the shell and the roof.

The period between two outside inspection depends on concrete conditions of a tank but according to [8] must not be longer than **1 month.**

3.2 Partial inspection

During the partial inspection the tanks can be exploited. It is recommendable that the partial inspection includes [4], [7]:

- knowledge of the technological documentation;
- visual control of construction, including weld joints;
- determination of the corrosion on the accessible shell surface, joint between shell and bottom, and tank roof;
- measurements of actual thickness of tank shell and roof elements;
-measurements of the deviations from the projected geometrical form and shell damages;
- visual control of the weld joints without their destruction;
- check for full contact of the periphery bottom part to the foundation;
- check of status of the tank foundation;
- check of the status of the surface around the tank, inclination, presence and drain of atmospheric water;
- control of the elements of the grounding system of the tank.

The discovered damages must be marked in a draft which is applied to the tank documentation.

After processing of the collected data about tank status, it is necessary that the verifying calculations must be done, including determination for remaining resource for safe exploitation. The actual status of the tank must be analyzed and the instructions for further exploitation, repairing work or stop of the exploitation must be prepared.

The period between the two inspections according to [8], must not be longer than 5 years or ¼ **from the remaining corrosion life of the shell**.

3.3 Complete inspection of the tank

The complete inspection aims to obtain complete estimation of tanks technical status. It is necessary to stop their exploitation. The tanks must be emptied, cleaned and aired according to the medical norms for safe peoples working. It is supposed that the following works must be done:

- knowledge of technological design and exploitation documentation;
- analyze of the geometrical deviations in the roof, shell and base for the exploitation period of the tank;
- inspection of the inside and outside surfaces and of all constructive tank elements, including the pontoon if there is any floating roof;
- measurement of the thickness of all constructive tank elements, discovering of areas where the corrosion damages are inadmissible;
- measurement of the distance between the construction and shell pontoon;
- measurement of the geometrical characteristic of constructive tank elements and to be reported this one which are not matching the admissible limits;
- determination of the kind and dimension of the settlement of foundation, determination of the unevenness of the settlement in the shell and the central bottom part. Determination of the status of the basement construction;
- inspection of anchors and the areas of their fixing;
- control of the quantity of the joints welded with physical methods;
- determination of the mechanical characteristics and critical temperature for fragile metal destruction in the areas with intensive corrosion and also in this parts where stress concentration is big;

- measurement of the thickness of the anticorrosion coverage;
- estimation of the velocity of the corrosion process in the area with intensive corrosion. Usually these areas are the first and the last shell courses [3];
- check for full contact of the annular part and central part of the bottom to the foundation;
- check of the soil around the tank, necessary declination presence and drain of the atmospheric water;
- discovered defects, damages and places of the repairing works must be marked in a draft which must be kept together with tank documentations;
- calculations which check the bearing possibility of the tank construction including determination of the shell resistance and check for earthquake influence ;
- determination of the remaining resource of the tank and determination of the mode and terms for the next inspection.

The period between two complete inspections depends on the discovered corrosion speed. According to [8] it is recommended that the actual periods between two inspections must assure minimal thickness of the bottom in the next inspection not less than:
- **2 mm** when the system for bottom leaks discovering miss;
- **1,3 mm** when there is a system for bottom leaks discovering.

Maximal period between the two complete inspections must be:
- when the corrosion speed is not known – **10 years**;
- when the corrosion speed is known – **20 years**.

Theoretical theses for determination of maximal period between two complete technical inspections of the tanks. [5].

The exploitation duration is determined by time during which the facility has its projected exploitation qualities. It is based upon its basic exploitation project.

Physical exploitation duration depends on its strength, its physical and technological characteristics and its parameters. Three periods of physical wearing out can be differentiated (fig. 1) :
- increased primary wearing out – Period (I) of basic load, pressure and deformation of the facility;
- slow and continuous wearing out – Period (II) of the normal exploitation, during which irreversible deformations are collected, caused structural changes of basic metal and welded joints;
- accelerated wearing out – Period (III), in the end of which wearing out reaches its critical point and arise the question whether the repairing and restoring works are expedients or the use of the facility or its elements will be stopped .

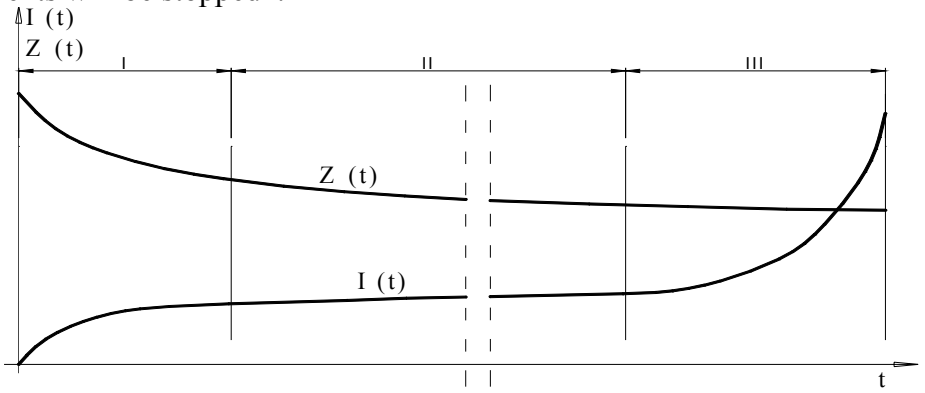

fig. 1 Physical wearing out **I (t)** and decrease of the strengths **Z (t)** в СВР

The methodology that calculates physical wearing out Q^f includes determination of the loss in the construction and invested in it materials and decrease of theirs physical and mechanical characteristics and bearing ability. It is calculated according to

(1) $$Q^f = \frac{\sum_{i=1}^{n} d_i . e^f}{100},$$

where:

d_i – relative part of the constructive elements value from its restoring value in % ;

e^f – index for physical wearing out of the constructive element, discovered during technical inspection of the facility in % .

Maximal value for wearing out of AST in exploitation can reach 80 %.

Moral wearing out of the tanks has two components:

- moral wearing out $\boldsymbol{M_1}$, which is due to the depreciation of facilities constructed long ago and has little practical signification. It is determined according to:

(2) $$M_1 = K_n - K ,$$

where:

K_n – value of new facility;

K – value of old facility.

- moral wearing out $\boldsymbol{M_2}$, due to the technological wearing out. The supplementary financial investments are needed for facility modernization and for putting it in accordance with contemporary technological and constructive requirements. It is calculated according to:

(3) $$M_2 = \Pi_2 . K = R_n ,$$

where:

Π_2 is an index in the second form of the wearing out;

R_n – financial investments for reconstruction and modernization which are provoked by moral wearing out.

The value of the moral wearing out $\boldsymbol{M_0}$ is obtained according to the sum $\boldsymbol{M_1}$ и $\boldsymbol{M_2}$:

(4) $$M_0 = M_1 + M_2 .$$

The best exploitation duration is determined by the period of facility use, during which period its recovering is expedient. This moment determines the end of tank use. (fig. 2).

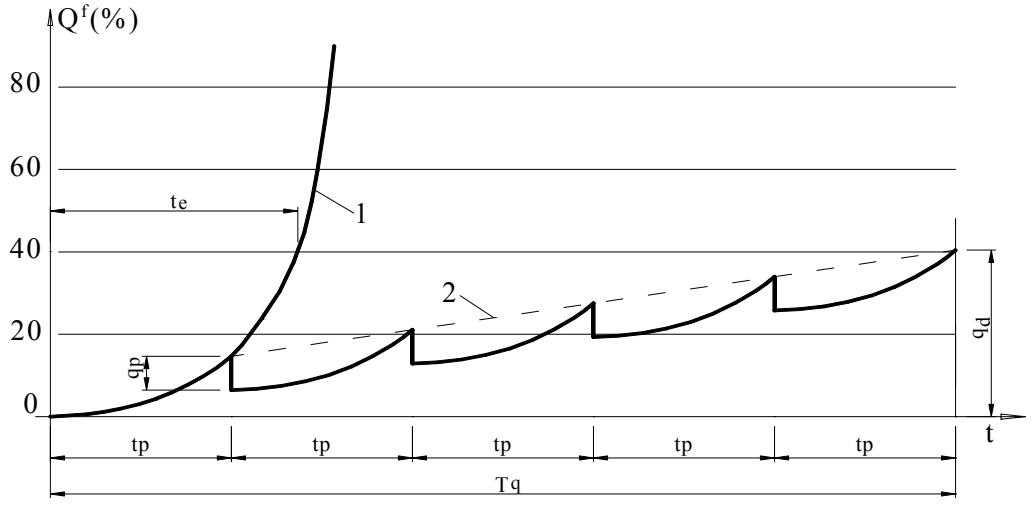

fig. 2 Scheme for determination of the period of the use $\boldsymbol{T_q}$ the period between repairing works $\boldsymbol{t_p}$

1. tank without repairing 2. periodically repaired tank

For practical purposes must be calculated the period between repairing works $\boldsymbol{t_p}$, for basement of the period between two complete inspections of the tanks and connected with them preventive repairing works. This period $\boldsymbol{t_p}$ must be determined according to:

(5) $$t_p = \frac{q_p . T_q}{\alpha . T_q + q_p - q_d}$$

(6) $$t_p = \frac{t_e - (1-k).T_q}{1-k},$$

where:

$q_p = \alpha \,.\, t$ – part, which decrease the wearing out on the account of the repairing works;

α – annual wearing out, % ;

t – period of the exploitation, years ;

t_e – period of the exploitation up to the reaching to the limit wearing out without executed repairing works, years ;

T_q – period of the exploitation up to the reaching to the limit wearing out with executed repairing works, years

k – part of remainder wearing out after repairing works;

q_d – admissible (limit) wearing out, % .

Participating in the formulas (5) and (6) quantities can be determined and / or accepted according to the special technical books following the technology [1] and organization [2] of the construction.

For the most of the participating quantities are determined the following values:

t = 25 years T_q = 30 years k = 0,75

t_e = 10 years q_d = 20 %

With this quantities, due to the equality between (5) and (6), for annual wearing out it is obtainede α = -1%. When за $\boldsymbol{q_p}$, it will be calculated:

$$q_p = \alpha.t = -0{,}01.25 = -0{,}25$$

So for the terms between two repairing works $\boldsymbol{t_{p1}}$ according to (5) and $\boldsymbol{t_{p2}}$ according to (6) it is calculated the following:

$$t_{p1} = \frac{-0{,}25.30}{-0{,}01.30 - 0{,}25 - 0{,}20} = \frac{-7{,}5}{-0{,}75} = 10$$

$$t_{p2} = \frac{10 - (1-0{,}75).30}{1-0{,}75} = \frac{2{,}5}{0{,}25} = 10$$

Therefore the calculated value for the period between the repairing works $\boldsymbol{t_p}$ with the accepted initial data is 10 years.

4. Criteria for the suitability of the tank for exploitation

The criteria for the suitability of the tank for further exploitation is the proved bearing ability of every separate part and the ability of all parts put together to bear loading in the future. For this purpose it must be done a complete analyze of the facility considering all the factors – inclination of the base, thickness of the elements, geometrical deviation in the wall and in the roof etc. The calculation of the tank must be done for the tank strength and the loss of the stability when it is loaded by its own weight, wind, snow, earthquake, appliance mounting and loading by the stored product.

5. Conclusion

The steel tanks are not eternal facilities. They bear the impact of uninterrupted corrosion activities from outsider atmospheric condition and stored product which decrease the thickness of the elements and break the integrity of the construction. Their inspections are obligatory. Settlement of the foundation and geometrical deviations influence unfavorably the facility, which must be reported by competent qualified persons. The correct analyze and competent repairing works reduce the risk for accidents and the environment pollution and make longer the period of their use.

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