

OVERALL INSPECTION AND INTEGRITY ASSESSMENT OF OIL AND OIL PRODUCTS STORAGE TANKS

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Steel tanks are widely used by oil & gas producing and transporting petrochemical companies and refineries for storage of oil and oil products. More than 2 thousand tanks having capacity from 100 up to 50 thousand m³ are being operated in Russia. Most of them were constructed mid 70th and beginning of the 80th of the last century and by now have come to the end of their design lifetime limited by 20 years. Operators perform inspection and repair of tanks on a regular basis and the issues of integrity assessment of these hazardous industrial facilities have crucial importance for them with a view of well-founded repair scope and time.

These challenging problems are solved based on results of tanks inspection, which as per the ruling document issued by Rostekhnadzor has to be performed not less than once every 4-5 years. Tank inspection is divided into partial, performed with no requirement for tank discharge, and the full one which needs tank decommissioning, cleaning and degassing.

As usually, partial inspection include:

- visual and instrumental inspection;
- ultrasonic thick measurements;
- ultrasonic weld control;
- acoustic control;
- leaktightness control;
- geodesic measurements;
- visual control of anticorrosion coating.

Full inspection in addition to partial inspection include:

- mechanical tests and metals chemical composition test;
- surplus pressure test;
- radiographic control;
- visual and ultrasonic control of inner constructions.

A considerable number of defects of storage tank structure are detected based on results of inspection which are impermissible as per the existing regulations, however not bringing the structure to the limiting condition.

Storage tank is a complex unit consisting of separate structures: wall, bottom, roof, floating roof, foundation, pipelines, auxiliary structures, attachments etc., which differ considerably both in respect of design as well as defects which may occur. Therefore, in order to assess integrity of a tank it is necessary first of all to examine each structure separately considering the defects found and tank operation conditions and after that interaction of the structures. Herewith it is necessary to consider product properties, loading cycles, filling level, wind and snow loads, environmental corrosiveness etc. It is evident that storage tank integrity assessment have to be performed consisting of several stages. At each of the stage the calculation and analysis of individual elements and structures have to be performed and after that the storage tank have to be considered as a whole. Tank integrity assessment procedure is shown on Fig. 1.

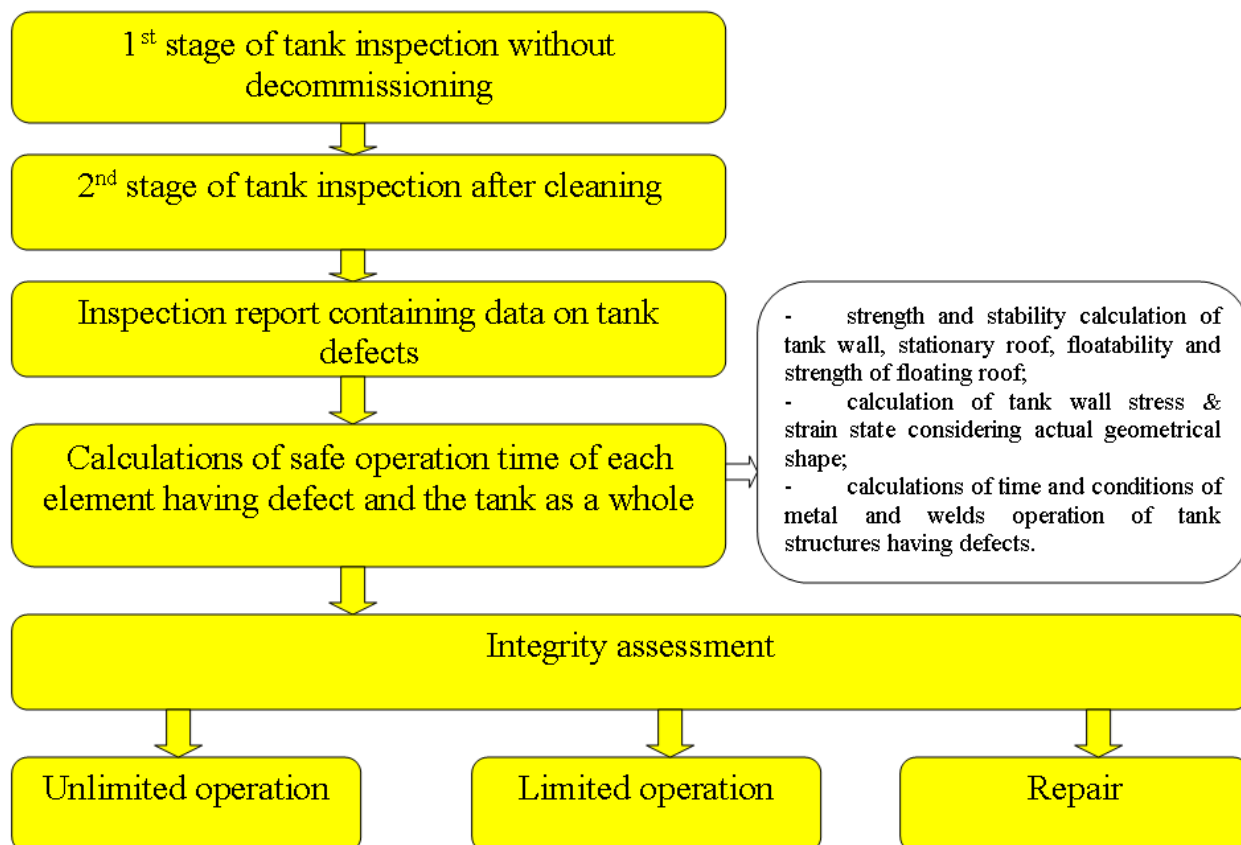


Fig.1 Tank integrity assessment procedure

Within the period of 2003- 2007 CJSC “VNIIST-Diagnostika” has developed and introduced technique of vertical storage tanks (VST) integrity assessment and a number of calculation methods, considering the above factors as well as presence of the following defects:

- dents, bulging;
- vertical deviations of wall elements;
- angularity of wall welds;
- sagging of tank bottom;
- uneven snow load on the roof;
- base metal defects, weld defects and others.

There are two main calculation types including defect influencing:

- calculation stress & strain state in defect zone;
- calculation the number of cycles for destruction and construction service life.

VST wall simulation and stress-deformed state calculations are performed in accordance with the developed method using ANSYS. The method includes procedure of creation of finite element grid, procedure of selection of its spacing, procedure of assessment of accuracy of the results received and some other constituents. The software considers geometrical parameters of VST wall, plate thickness variation depending on its height, mechanical properties of wall plates steel, as well as operation loads.

Let show some examples for illustration practical results of technology.

After inspection VST -10000 m³ dent (height 4800 mm, length 2800 mm, depth 65 mm) has been detected (fig.2). Tank with such defects can not be allowed to operation, dent has to be removed.

The results of using technology are showed on fig.3. It has been established, that in actual operation conditions and real wall shape stress in dent zone not more than 136 MPa. Allowed stress is 162 MPa. Stress in dent less than allowed so VST-10000 can be operated with dent.

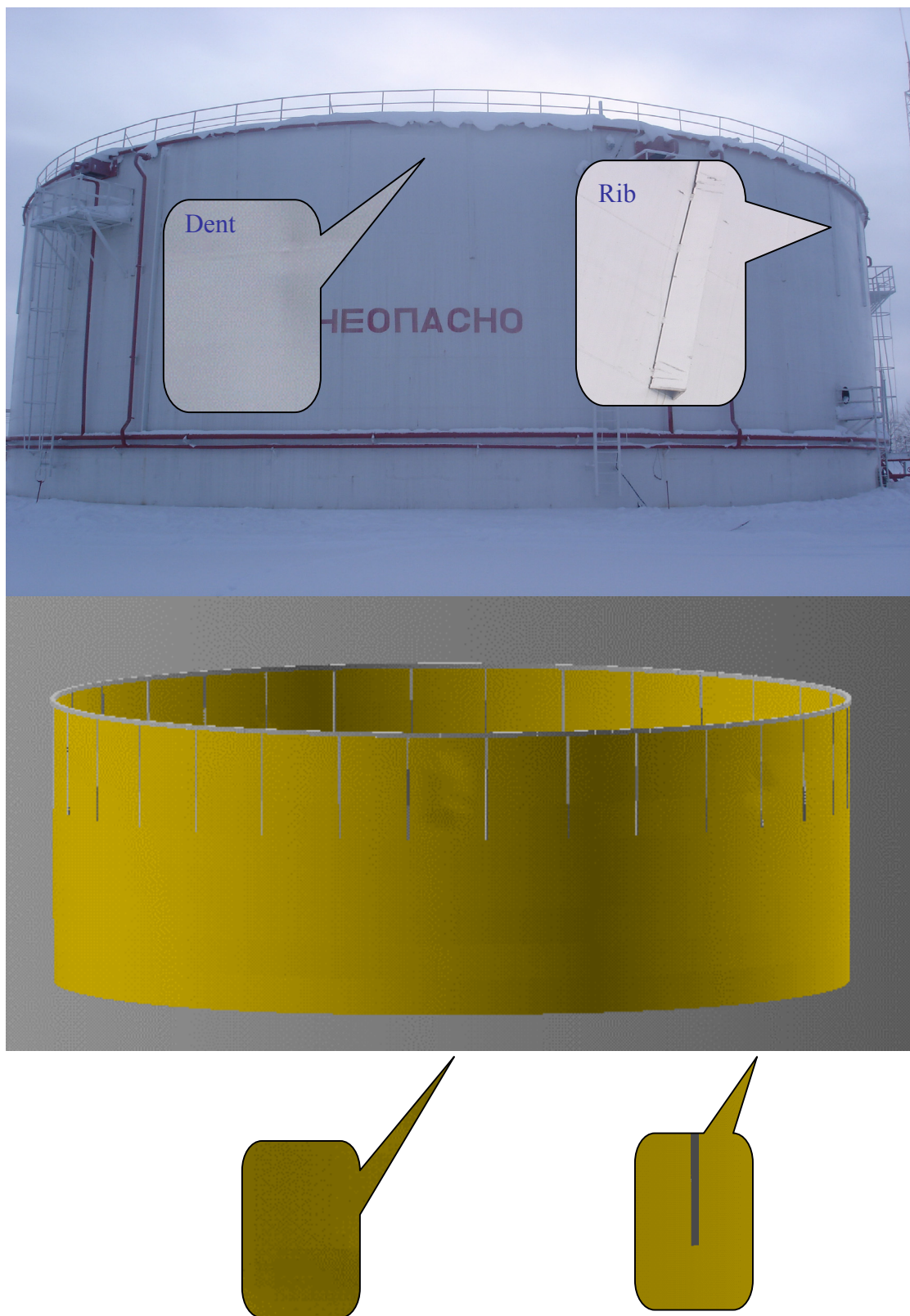


Fig. 2 Photography and finite elements model of VST-10000 wall with defects

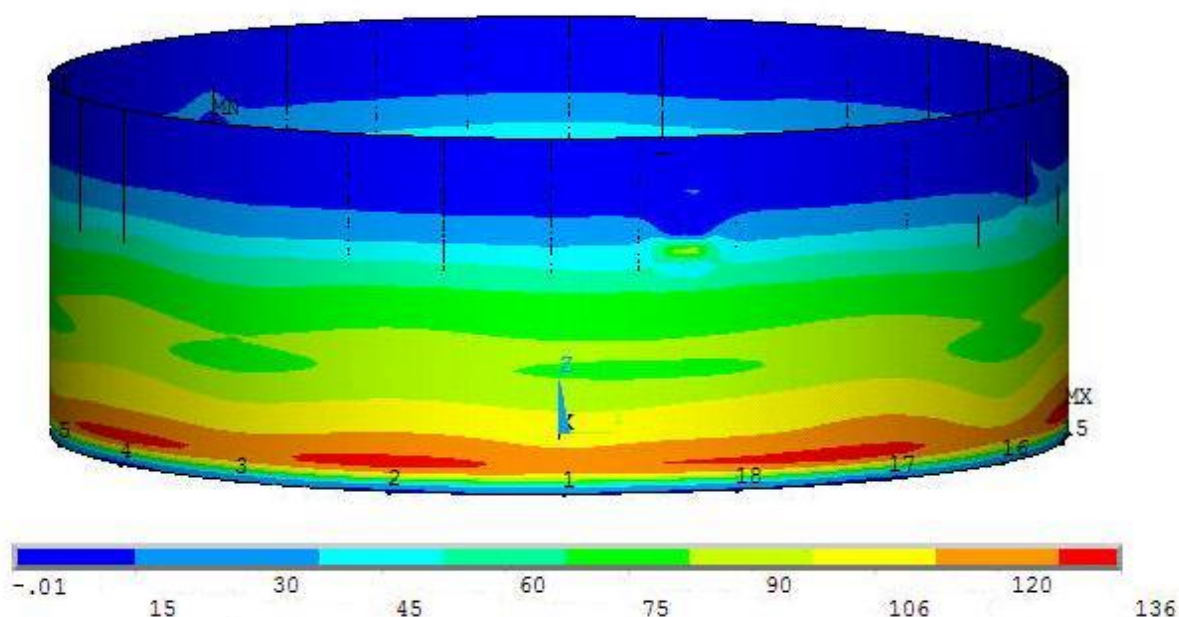


Fig. 3 Result of stress calculation VST-10000

Stress in defect of metal and wall was established after calculation. It allow to calculate destruction time for every elements with defect. Sample is shown at table 1.

Table 1.

Element	Nomb er of defect	Defect	Parameters, mm	Location	Stress, MPa	Service life, year
Wall – service life – 4,4 year						
Wall	1	Corrosion	500×1500×1	Sheet №23 X = 0 Y = 750	136	19
Welds	2	Undercut	15 x 1	Sheet №8 X = 0 Y = 1160	130	>20
	3	Torn surface	10 x 2,5	Sheet №3 X = 210 Y = 0	117	>20
	4	Pinhole cluster	20 x 1 x 2	Sheet №15 X = 2730 Y = 0	100	>20
	5	Internal defect	50 x 4	G1, 2730 mm from V5	115	15
	6	Internal defect	40 x 5	G1, 2300 mm from V9	120	4,4

Recommendations for future operation are produced based on results of conclusion. For VST-10000 it can be formulated: tank can be operated without repaid for 4,4 year. If defect 6 will be removed, then service life can be increased to 15 years.

Lets show one more sample. There are results of stress conclusion for wall VST-20000 with 4 defects: 3 dent and angularity. All defects are inadmissible.

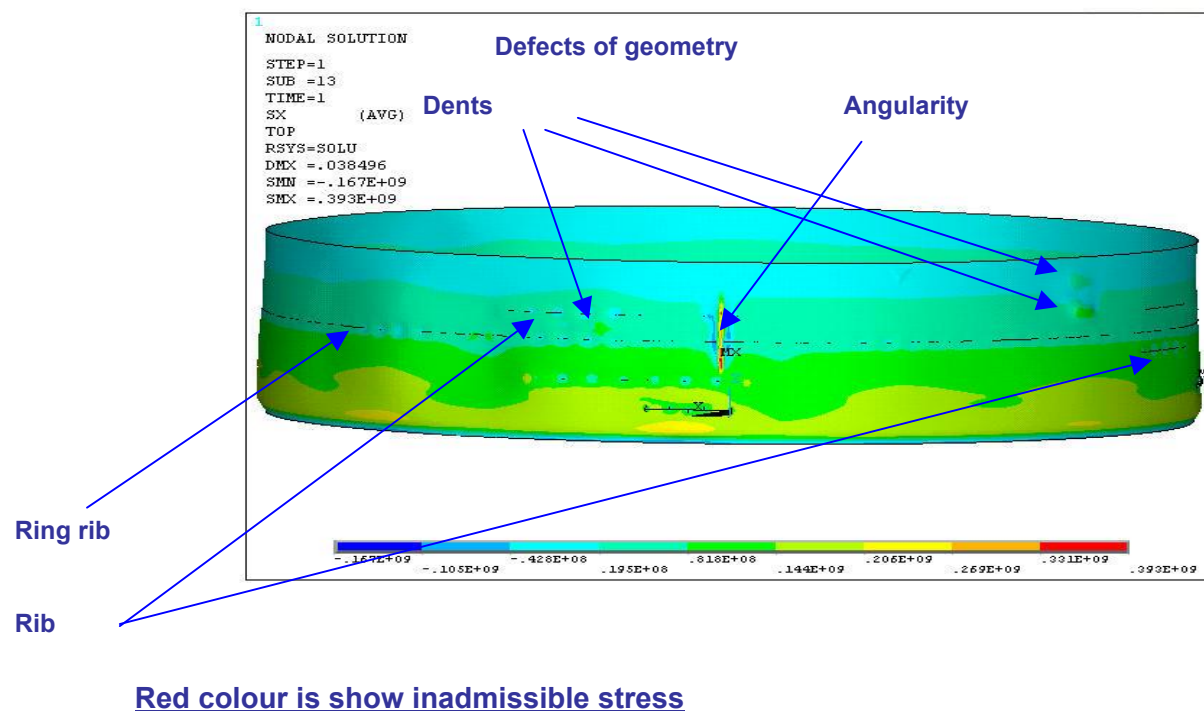


Fig. 4 Result of stress calculation VST-20000

The results of calculation show, that stress in dent zones less, than critical and stress in angularity zone more, than critical. So, the tank can be operated without removing dent. But if operator want do not remove angularity, he must decrease oil level to 7.5 m. If higher level is necessary, the angularity has to be removed.

Conclusion.

The technique developed for tank integrity assessment and the method of stress-deformed state calculation of its structures allow for assessment of severity of defects, detected during inspection depending on actual tank operation conditions.

The proposed techniques can be used during development of feasibility study of repair expediency depending on after repair tank operation. Therefore operator shall obtain instrument allowing to take well-founded decision based on inspection data and integrity assessment considering tank farm utilization, financial and technical feasibility to continue operation of VST without repair, to perform maintenance or overhaul repair or dismantle the tank.

Based on results of calculations performed by CJSC “VNIIST-Diagnostika” in 2007-2008 operation of about 40 tanks had been extended and the scope of repair work of 60 tanks considerably reduced.

Prescribe:

1 RD 08-95-95 Regulations about system of technical diagnostic of VST for oil and oil products.