

1.13.6. CALCULATION OF SERVICE'S CONDITIONS OF WALL OF VERTICAL CYLINDRICAL TANKS WITH GEOMETRICAL DEFECTS

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The existing regulation documents establish criteria of allowable defects of vertical steel tanks. However operators not always have a possibility to immediately perform repair. In order to continue operation of tanks having non-compliant wall geometry deviations stress-deformed state calculation has to be performed and it has to be confirmed that:

1. Wall metal has no ultimate stress.
2. There is no wall stability loss, including local loss of stability (buckling).

The present article present method, developed by CJSC “VNIIST-Diagnostika” which makes possible to determine allowable operations conditions of VST having wall defects based on the example of calculation of stress-deformed state of tank wall having dents of various depth.

As a case study for calculation of stress-deformed state vertical steel tank with floating roof has been selected VSTFR-10000 having capacity of 10,000 m³. There are hundreds of such tanks available with various oil and gas producing and transporting companies. Therefore, stress-deformed state calculations of VST wall are crucial for assessment of resource to operate them safely.

A series of calculations have been performed in order to determine dependence of stress-deformed state of tank wall on maximum dent tongue. During calculations the maximum dent tongue ($F_{\max}$) was set from 7.8 mm up to 273 mm with a step of 7.8 mm; all in all 35 dents have been created having equal width, height, shape, same location on the tank wall and different as far as dent tongues were concerned.

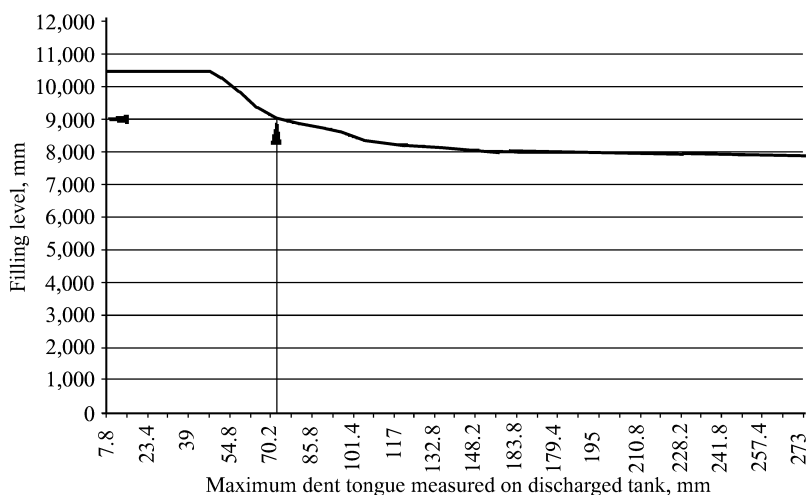


Fig. 1. Dependence of the allowable filling level on maximum dent tongue

Surface stresses during dent tongue measurement from 7.8 mm up to 50.9 mm grow in accordance with dependence close to linear, and with dent tongue value of 50.9 mm reach steel yield point (245 MPa). Further increase of dent tongue causes appearance of plastic deformations on metal surface in the central lower part of dent.

Middle stresses increase with grow of dent tongue with dependence close to linear and exceed the allowable values (162 MPa) at dent tongue value of 85.8 mm.

Dent depth values have been determined at which there is a local loss of stability – from 124.8 mm up to 241.8 mm.

Therefore, the maximum allowable dent tongue value having set parameters (width, height, shape, wall location etc.) during operation of VSTFR-10000 with design filling level for criterion of ultimate stresses and absence of stability loss shall be 50.9 mm, at maximum allowable compliant value of 39 mm.

Calculations have been performed in order to determine the possibility of tank operation having large dents by lowering filling level (fig. 1). For example, in order to continue operation of the tank having dent with depth of 78 mm it is required to limit filling up to 9 m and for dent with depth of 150 mm – up to 8.1 m.

The method developed makes possible calculate allowable conditions of VST operation having wall defects (load, filling level etc.). The Finding issued based on such calculation allows to take a well-founded decision on feasibility and conditions of further safe operation of VST and determine the scope of repair required.