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# TESTING, DAMAGE REPAIR AND ASSESSMENT SAFETY AND RELIABILITY OF SPHERICAL TANK STORAGE FOR EXPLOITATION'S EXTENSION OF LIFE

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## SUMMARY
*The paper describes the procedure of defect, damage recovery and examination after successful completion of the sanation of a spherical ammonia storage tank at the plant Fertilizer in coke industry Lukavac. Defect's inspection was carried out by conducting destructive testing, which was carried out repairs to damaged material. Repair of damage was done according to the prescribed welding technology. Once again, after sanation in areas of rehabilitation, were conducted pressure test and measurement stress states of spherical tank. The analysis of the results shows the integrity of the storage tank, and thus ensure the reliability and security of its further exploitation.*
**Keywords:** spherical tank, construction, testing, repairing damage, security, the term of exploitation

## 1. INTRODUCTION
In the exploitation of storage tanks, special attention should be given to safety and security. As this is a facility intended for the storage of ammonia, which is stored under a certain pressure, there are clear rules that provide control over them and monitor safety during operation to ensure maximum reliability and safety to prevent breakdowns.
Evaluation of the state of material storage tank is monitored at regular intervals on the basis of conducted examinations and tests. The requirements are mainly related to testing (measuring) the state of stress. Testing stress condition was done by electrical resistance strain gauges at the working and test pressures, with the preliminary examination of welds and test wall thickness.

## 2. TESTING AND REPAIR OF DAMAGE
Spherical tank for storing ammonia was examined in accordance with a prescribed program of tests and applicable standards and regulations. Tests were performed with nondestructive methods according to instructions and regulations for the periodic inspection. There were applied penetrating, ultrasonic and magnetoflux methods. In some places of the storage tank were discovered corrosion damages in depth of 5-10 mm, especially in section 18 and 21 of the part VII. In section 19 of the part VII damages showed concentration of a large number of small cracks, so that made crop a plate size 190 x 280 mm. Local damages sanation was done by welding and replacement of damaged and diced segments was done by welding, manual arc welding process according to the prescribed technology.

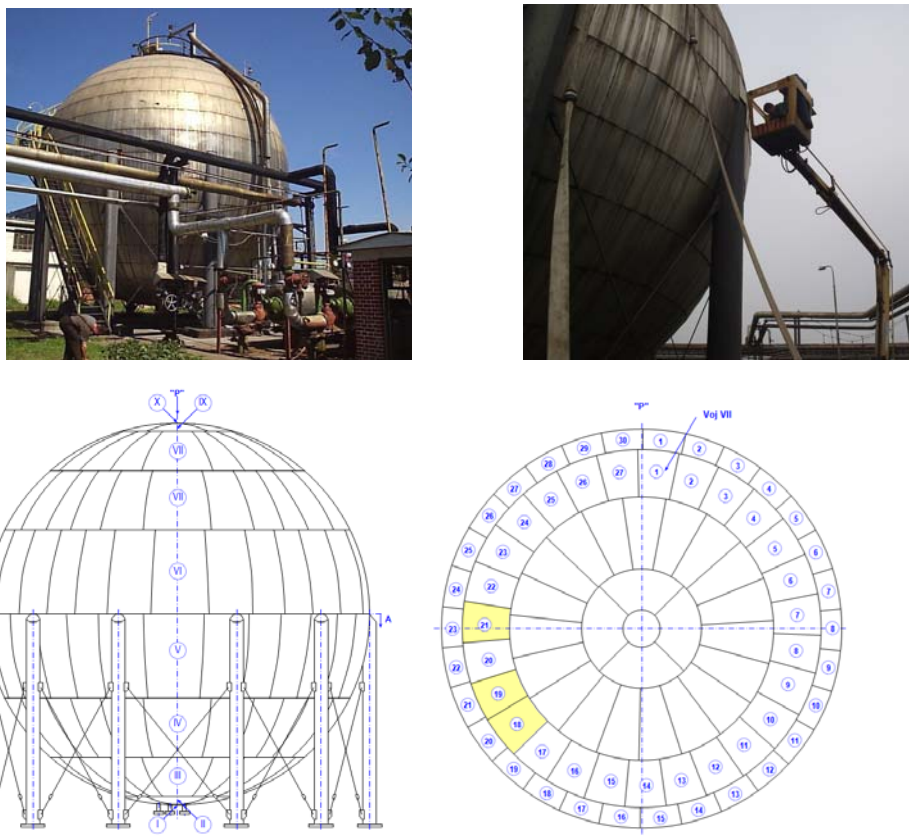


*Figure 1. Spherical tank for ammonia storage and testing scheme*

According to the technical documentation (documentation attesting the material it was made reservoir - Report No. 28512 - "Duro Đaković" Slavonski Brod; Report of HB Zenica; Expert opinion No. 21/05 - MI "Kemal" Zenica and the Study on the completed trials sphere for storing ammonia in January 1996) of spherical tank for storing ammonia is made from materials Asher 48 corresponding steel quality CRO 350 (JUS C. B0. 502 from 1979th years.).

*Table 1. Chemical composition and mechanical properties of materials*

Chemical composition:

| Materijal | C [%] | Si [%] | Mn [%] | P [%] | S [%] | Cr [%] | Mo [%] | Ni [%] | V [%] | Cu [%] |
|---|---|---|---|---|---|---|---|---|---|---|
| ASERA 48 | 0,16 | 0,22 | 0,86 | 0,035 | 0,040 | 0,13 | 0,02 | 0,15 | 0,10 | 0,21 |
| NIOVAL 47 | 0,18 | 0,39 | 1,45 | 0,013 | 0,016 | 0,16 | 0,02 | 0,19 | 0,06 | 0,16 |

Mechanical properties:

| Materijal | Rp [N/mm$^2$] | Rm [N/mm$^2$] | $A_5$ [%] | [%] | |
|---|---|---|---|---|---|
| ASERA 48 | 481 | 651 | 17 | 29 | |
| NIOVAL 47 | 471 | 634 | 31 | 53 | |

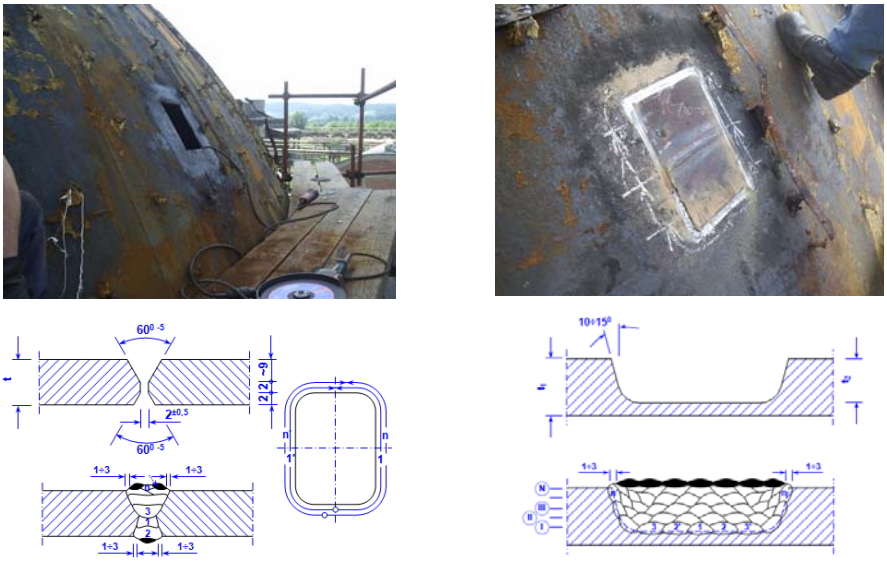

*Figure 2. Repair of damage of the spherical tank*

## 3. SELECTION OF MEASUREMENT POINTS AND PERFORMANCE TESTING

Measurement points for the testing stress condition located on a spherical tank in the zones, where the examinations and tests, visual control and ultrasonic measurement of wall thickness was made.In these zones has been observed a weakening of spherical tank construction due to exploitation. Measuring tapes are placed on the principal stress directions.

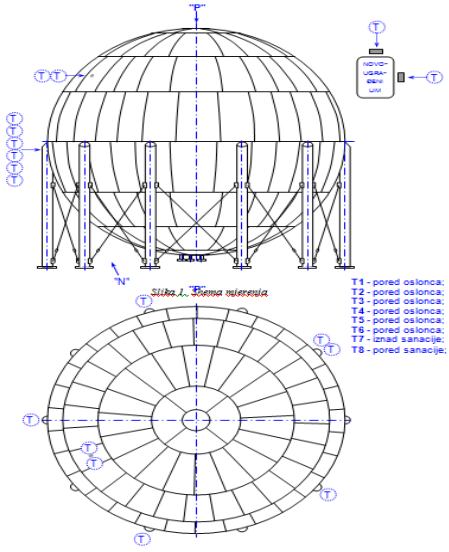


*Figure 3. Measurement sheme*

## 4. TEST RESULTS

The study was performed like we planned and during the investigation was monitored the parameters that is functionally related to deformations or stresses. Budget stress is performed by obascu: (E - modulus of elasticity, ε - elongation). Results of measuring strain and stress conditions in the measuring points T1 ÷ T8 are given in Table 2.

*Table 2. The values of the test pressures and the stress (20 $^0$C)*

| Stress | T1 | T2 | T3 | T4 | T5 | T6 | T7 | T8 |
|---|---|---|---|---|---|---|---|---|
| | $\sigma_{i1}$ | $\sigma_{i2}$ | $\sigma_{i3}$ | $\sigma_{i4}$ | $\sigma_{i5}$ | $\sigma_{i6}$ | $\sigma_{i7}$ | $\sigma_{i8}$ |
| [MPa] | [MPa] | [MPa] | [MPa] | [MPa] | [MPa] | [MPa] | [MPa] | [MPa] |
| 0,00 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Hydrostatic pressure | 14 | 19 | 21 | 18 | 13 | 20 | 14 | 2 |
| 0,30 | 47 | 38 | 32 | 44 | 109 | 70 | 127 | 127 |
| 0,48 | 68 | 60 | 51 | 65 | 153 | 99 | 197 | 195 |
| 0,65 | 98 | 89 | 79 | 96 | 205 | 168 | 216 | 223 |
| 0,48 | 67 | 60 | 50 | 65 | 154 | 142 | 201 | 199 |
| 0,30 | 36 | 30 | 19 | 33 | 100 | 81 | 149 | 139 |
| Hydrostatic pressure | 13 | 17 | 30 | 17 | 13 | 21 | 64 | 33 |
| 0,00 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

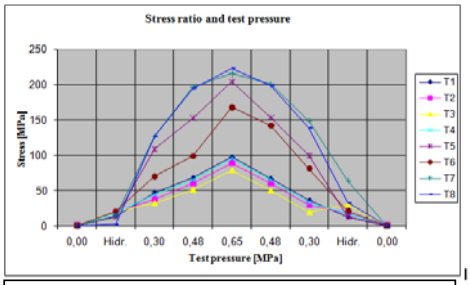


Figure 3 Diagram of the test pressures and the stress

## 5. ANALYSIS OF TEST RESULTS

Analyzing the results of the measured strain given in tabular overview, starting from the theory of elasticity and the assumption that the strains and stresses are within the elastic limit using Hooke 's law, where σ = E x ε [N/mm2], at the working (P = 0.48 MPa) and test pressures (P = 0.65 MPa) at certain points of the spherical tank we get maximum stress states:

*Table 3. Maximum value of the measured stress*

| Strain [MPa] | Measuring position T5 $\sigma_i$ [MPa] | Measuring position T7 $\sigma_i$ [MPa] | Measuring position T8 $\sigma_i$ [MPa] |
|---|---|---|---|
| 0,48 | 154 | 201 | 199 |
| 0,65 | 205 | 216 | 223 |

The measurement points are located in the zone of the leg (T5) and in part VII opment mantle storage tank in the area of sanation of damage (T7 and T8). Residual stresses registered at measuring points T2, T4 and T6, are within tolerable limits and those are caused by changes in temperature during the tests and rapid relief of tank. Taking into consideration the elasticity of the material from which the spherical tank made and maximum measured stress state, it can be concluded that the maximum stress conditions are within tolerable limits. $\boldsymbol{\sigma_{imax} = 223\ MPa < \sigma_e = 335\ MPa}$

## 6. CONCLUSION

The success of extending the life of the use of spherical tanks basically boils down to the problem of timely identifying the damage and determining the dynamics of their growth. Growth dynamics of damage can be successfully monitored only with the help of organized and consistent-existing one monitoring system material behavior of the system in operation. On the basis of such a system on a real spherical tank can investigate and determine the legality of the growth clear damage. On the basis of this system can also be assessed and the time allowed, and achieve critical size.

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