

The safe operating life of isothermal steel vessels for dock storages of liquid ammonia

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ABSTRACT

The report considers the problems of life evaluation for the steel isothermal vessels intended for storing of liquid ammonia in connection with their operating conditions. It was determined that in the process of long-term service (up to 30 years) the stress-corrosion damages and structural changes of metal and welded joints of the internal vessel filled with liquid ammonia do not take place. Formation and growth of fatigue cracks as a result of cyclic loading caused by change in height of product filling are regarded as the main probable factor of vessel material damageability. The possibility of normative period refinement for periodical inspection of technical state of ammonia storages with emptying of internal vessel from product is shown by the example of operating life calculation of typical isothermal storage of liquid ammonia with a volume of 20,000 m³.

KEY WORDS: Vessel; steel; ammonia; temperature; cracking resistance; life; strength.

INTRODUCTION

Storing of liquid ammonia in the dock stores is carried out in the steel vertical isothermal storages having a double-wall construction with a volume of 20,000 m³ and more. For majority of such storages built in the seventies-eighties the schedule guideline life expired and therefore the problem consisting in definition of possibility of their further operating life is of high priority. At present decision on prolongation of the operating life of isothermal storages is made on the basis of results of integrated inspection of their technical state which is carried out in accordance with the current rules every 6-10 years. In this case the obligatory emptying of internal vessel from ammonia is ordered to carry out its technical state inspection services. The fixed dates of regular inspections of internal vessel as well as methods and amounts of inspection appointed without considering conditions of vessel loading, predictable types of probable damages of metal structures and data of continuous monitoring realized by traffic department have no proper justification up to present time. Meanwhile, decommissioning of isothermal storages with a volume of 20,000 m³ and more for carrying out inspection of metal structures and their following commissioning is a sufficiently long (1.5-2.0 months) and labour-intensive process and can result in unjustified costs of enterprises. In addition, the considerable elasto-plastic deformations arising in the metal structures of bottom, wall and roof caused by temperature drop equal to 45-50°C

can result in the irreversible damages of metal structures as well as adversely affect the state of heat-insulating materials and foundations under the internal bottom and eventually cause decrease in general resource of storage operation.

The given report presents the matters of calculation assessment of the safe operating life of internal shell of liquid ammonia storages and potentialities for refinement of period for their periodical inspection on the basis of results of the full-scale technical state investigations and laboratory research.

ON RESULTS OF TECHNICAL DIAGNOSTICS OF VESSELS

To assess the safe operating life of vessels, it is necessary to identify the main types of probable damages of metal structures in the process of their continuous service which can result in leakage of the internal shell or loss of its carrying capacity. The probable types of damages in the base metal and welded joints of internal shell are:

- decrease in thickness of the vessel wall and bottom because of metal corrosion;
- stress-corrosion cracking of the welded joints under action of stress caused by long-term exposure of product;
- decrease in mechanical properties of metal and its embrittlement caused by long-term exposure of product;
- formation of fatigue cracks because of cyclic loading of vessel caused by changes in height of ammonia filling in the process of long-term service.

On the basis of data on the on-site inspections and laboratory research of the metal damageability regularities in the operating environment of liquid ammonia accumulated by the present time it is practical to consider impact of each of the listed above factors on the safe operating life of internal shell of isothermal storages.

Under service conditions the metal structures of internal shell have a temperature of minus 33°C. To avoid generation of condensate on the outer surface of internal shell wall, the insulation space is blown by gaseous nitrogen. Therefore the conditions for development of corrosion damages of metal are absent. This fact is confirmed both by results of ultrasonic thickness measuring and by data of visual examination. The tracks of surface uniform corrosion of wall metal observable during inspection arise in the process of vessel decommissioning and transition to the positive temperatures of wall. In