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Study of Durability of Porous Polymer Materials, Glass-Fiber-Reinforced Polyurethane Foam (R-PUF) in MarkIII Containment Membrane System

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Abstract : The insulation of MarkIII membrane of the Liquid Natural Gas Carriers (LNGC) consists of a load- bearing system made of panels in reinforced polyurethane foam (R-PUF). During the shipping, the cargo containment shall be potentially subject to risk events which can be water leakage through the wall ballast tank. The aim of these present works is to further develop understanding of water transfer mechanisms and water effect on properties of R-PUF. This multi-scale approach contributes to improve the durability. Macroscale / Mesoscale Firstly, the use of the gravimetric technique has allowed to define, at room temperature, the water transfer mechanisms and kinetic diffusion, in the R-PUF. The solubility follows a first kinetic fast growing connected to the water absorption by the micro-porosity, and then evolves linearly slowly, this second stage is connected to molecular diffusion and dissolution of water in the dense membranes polyurethane. Secondly, in the purpose of improving the understanding of the transfer mechanism, the study of the evolution of the buoyant force has been established. It allowed to identify the effect of the balance of total and partial pressure of mixture gas contained in pores surface. Mesoscale / Microscale The differential scanning calorimetry (DSC) and Dynamical Mechanical Analysis (DMA), have been used to investigate the hydration of the hard and soft segments of the polyurethane matrix. The purpose was to identify the sensitivity of these two phases. It been shown that the glass transition temperatures shifts towards the low temperatures when the solubility of the water increases. These observations permit to conclude to a plasticization of the polymer matrix. Microscale The Fourier Transform Infrared (FTIR) study has been used to investigate the characterization of functional groups on the edge, the center and mid-way of the sample according the duration of submersion. More water there is in the material, more the water fix themselves on the urethanes groups and more specifically on amide groups. The pic of C=O urethane shifts at lower frequencies quickly before 24 hours of submersion then grows slowly. The intensity of the pic decreases more flatly after that.

Keywords : porous materials, water sorption, glass transition temperature, DSC, DMA, FTIR, transfer mechanisms
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