FLOATING MEMBRANE ROOF for large zootechnic and industrial storage tanks

The biogas sector had a rapid development in the last decade with several new industrial plants realized all over Europe and Worldwide. The intrinsic efficiency of membrane structures provided a cost-effective solution to cover digesters, bio-filters, lagoons and gas holders through different concepts such as floating membranes, anticlastic geometries and pneumatic structures.

The most challenging applications for biogas plants are the membrane roof for large lagoons and storage tanks designed to store the sewage after it has been treated. The most common shape is circular but elliptical and rectangular plans are also adopted in specific situations. For this application, the membrane roof protects the tank from rainwater and prevents the release of gas and smell in the atmosphere. In recent years, local environmental regulations became more stringent regarding the emissions released into the atmosphere and the current membrane structures do not always meet the new criteria.

In 2021 Maco Technology srl secured financial support (POR FESR 2014-2020: ASSE I – AZIONE I.1.B.1.2. BANDO "TECH FAST LOMBARDIA") for the development of a prototype able to address the limits of the current products and investigate the technical and financial viability of a new type of roof for zootechnic and industrial large storage tanks. The pilot project was carried out in collaboration with the University of Nottingham and Acqua e Sole srl and a 1:1 scale prototype was installed in the North of Italy in a circular metal storage tank 64m in diameter and 18m high.

The new, patent-pending, concept is based on a floating roof made of modular PET cubes and rectangular cuboids commonly used for floating pontoons cladded with an airtight membrane. The forces are transferred to the tank through low-friction wheels connected to the floating deck by means of rigid steel reinforcements designed to spread the load across multiple PET floating units. The membrane roof is manufactured in one single piece using a PVC-coated polyester fabric optimized for biogas applications. The membrane is connected to the floating deck by means of a tubular edge ring connected to the PET modules by means of a polyester webbing system tensioned through removable ratchets. The edge ring provides a barrier for the rainwater which is conveyed in dedicated areas for drainage by means of water pumps. The effective drainage of the rainwater avoids the dilution of the stored liquid and the consequent associated costs.

The airtightness of the membrane cladding is achieved by means of a hermetic clamping to the steel reinforcements and thanks to an immersed membrane flap which prevents the passage of the gas. The gas is drained from two points connected to a low-pressure blower. The design of the PET modules provides adequate space for the unleashing of the gas from the liquid and circulation under the membrane cladding. In tanks covered by fixed roofs, the volume and the pressure of the gas trapped between the liquid and the roof varies according to the level of the liquid. This creates the risk of oxygen infiltrations (due to the negative pressure due to a decreasing liquid level) which, combined with the large volumes of gas accumulated, could result in a high risk of explosions. In the proposed new concept, the floating deck creates a limited volume for the accumulation of gas between the membrane and the liquid which remain constant despite the variation in the liquid level. The result is a safe and effective way to prevent the release of gas into the atmosphere and 10% increase in the total gas output of the biogas plant. The structure has been successfully monitored for 12 months, the level of purity of the methane gas is over 90% and the air infiltrations are negligible despite the size of the membrane roof. The positive results achieved confirmed the technical and financial viability of the idea and lead to the commercialisation of the new, patent-pending, product on the market.

Figure 1. The aerial view of the biogas plant
Figure 2. The floating deck under construction
Figure 3. Detail of the steel reinforcement
Figure 4. The positioning of the membrane roof
Figure 5. The membrane roof ready to be deployed
Figure 6. The detail of the tensioning system and the protective layers around the perimeter of the floating deck
Figure 7. The tensioned membrane roof

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