S2.2.3 ASSESSMENT OF MEMBRANE LIFE VIA FATIGUE TESTING

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As low-pressure (microfiltration and ultrafiltration) membranes are increasingly used for water and wastewater treatment, assessing membrane service life becomes an important task. Low-pressure membranes experience repeated mechanical and chemical stresses as the operation cycles through filtration and cleaning (hydraulically and chemically. Those stresses can lead to the weakening of polymeric membranes, and ultimately the membrane failure as a result of losing membrane integrity and its ability to remove targeted contaminants. Conducting fatigue test can provide a method to predict when the fatigue failure may happen. Conversely, given a definitive goal of required service life for a polymeric membrane, fatigue test can be used to optimize operating conditions to meet the specified criterion. The major factors affecting membrane fatigue include membrane medium composition, architecture, morphology, and construction, and operating characteristics and environment.

Historically, fatigue test has long be used to testing metallic materials such as cast irons, aluminum, steel, and metal alloys. As the polymeric membranes are made of high molecular-weight polymers, they exhibit more complex behaviors than the classic elastic materials. Especially, the viscoelastic nature of polymeric membranes can have a damping effect for the stress, but typically with a hysteretic response to the cyclic change of the stress. Those features have to be considered in designing fatigue tests for low-pressure membranes. One approach is accelerated fatigue test where the testing conditions are closely resemble to those used in actual operating conditions with a much accelerated pace.

Chemical attack from either the treatment processes or membrane cleaning operation is another major reason for membrane fatigue failure. Chemical attack changes the mechanical properties of polymeric membranes by modifying the micro-scale structure of membranes. For example, chemical attack of polyvinylidene fluoride (PVDF) membranes by caustic can lead to the formation of carbon – carbon double bonds that limit the rotation movement of polymer chains. As a result, membranes become more brittle, which can be more easily fractured under the mechanical stress. The difficulties to design chemical fatigue test include to project long-term, low concentration exposure of membranes to chemical using a model based on short-term, high concentration exposure test, the presence of stimulants and/or retardants of chemical reactions, and synergetic effects of chemical and mechanical stresses, and stochastic nature of fatigue failure.