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Reliability Design Methodology for High Pressure Inflatable Structures

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ABSTRACT

Occasionally, large diameter pipes and tunnels need to be sealed to prevent the flow of liquids or gases through it in case of unexpected event or failure of the system. Potential applications include large water and sewage pipes, large conduits for industrial fluids, rail and automobile tunnels, etc., that might be vulnerable to unexpected system failures that require temporary closure. For example, flooding of a freight tunnel in downtown Chicago and the buildings connected to these tunnels, forced evacuation of more than 250,000 people [1]. The Chicago tunnels have a cross section of 2.8 x 1.3 m and at the time of the accident they represented a network of more than 80 km that was used to run freight, television, telephone, and power conduits. Pumping off all water from the tunnel system took five and a half weeks at a cost of $40 million [2]. Although it is difficult to prevent all situations that can lead to such threatening events, damage can be substantially minimized by compartmentalizing the region affected by the event. However, usually there is no space in existing facilities for installing permanent gates. In addition, the cost of interrupting the operation of the facility to install gates would be prohibitive. Therefore, a simpler solution was sought in this work.

A design methodology for a high-pressure inflatable structure is proposed. The inflatable structure may be partially confined inside a cavity. The design methodology is based on the concept of limit states. Second order reliability analysis is proposed to deal with different statistical distributions for the various loads and resistances that affect the design. The analysis is simplified to a load resistance factor design (LRFD) assuming that all stochastic variables conform to similar distribution functions. In this later case, a methodology to calculate the resistance factors in terms of the experimental data is presented by using the concept of basis-values, also presenting a procedure to calculate basis-values other than A- and B-basis. A rationale for this approach and the need to expand the coverage to cases other than A- and B-basis is provided.

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