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Abstract

The protection of structural steel on exposure to a fire has become paramount to prevent the loss of lives and assets with increasing use of structural steel as a material to create the shape of construction projects. Structural steel loses bearing ability when its temperature exceeds 500 °C (failure temperature), and an efficient way to prolong the time before the failure temperature is reached is to use intumescent coatings. At elevated temperature, intumescent coatings swell, via a complex chemical mechanism, to a porous multicellular char layer that acts as a thermal shield protecting the underlying substrate. For the special case of hydrocarbon fires on oil rigs, so-called hydrocarbon intumescent coatings are used, which must also be able to withstand jet fires after expansion.

The crucial assessment of intumescent coatings is fire testing that is usually done with big industrial furnaces under standard temperature-time curves. However, the industrial fire tests have shortcomings of high costs, poor repeatability, and longtime cooling demand between two tests. These factors limit standard fire tests, especially for hydrocarbon fires. Therefore, a small-scale and high-throughput fire testing is badly needed to favor the assessment and development of effective intumescent coatings.

The fire testing that we have developed is based on a lab-scale oven that can be rapidly heated up to 1600 °C within 10 minutes. The standard fire curve mimicked by this oven is UL 1709, which is a widely accepted hydrocarbon fire-testing curve for intumescent coatings. The samples for tests are prepared by applying about 6 mm intumescent coating on the surface of a grit−blasted steel plate. A thermocouple is attached to the back of the plate to record the temperature-time (T-t) relationship during the fire testing.

According to the chamber temperature recorded during each fire test, this oven can adequately simulate the T-t curve defined in the standard. The relative standard deviations of the time for the steel plate to reach 400 and 550 °C are less than 1%. Seven intumescent coatings will be used for experimentation in the lab oven and in industrial furnaces to link their performance and verify credibility of the lab oven for the fire tests under standard fire curves. Two coatings have presently been evaluated and the results indicate a high consistency between the lab oven and the industrial furnace with respect to the temperature- time relationship. This suggests that the lab oven is a promising small-scale solution for the standard fire tests. Additional experiments will be conducted to investigate the influence of coating ingredients on the intumescence performance and shed light on the intumescence mechanisms.

Keywords: fire protection; hydrocarbon intumescent coatings; standard fire test.