E²G INDUSTRY INSIGHTS

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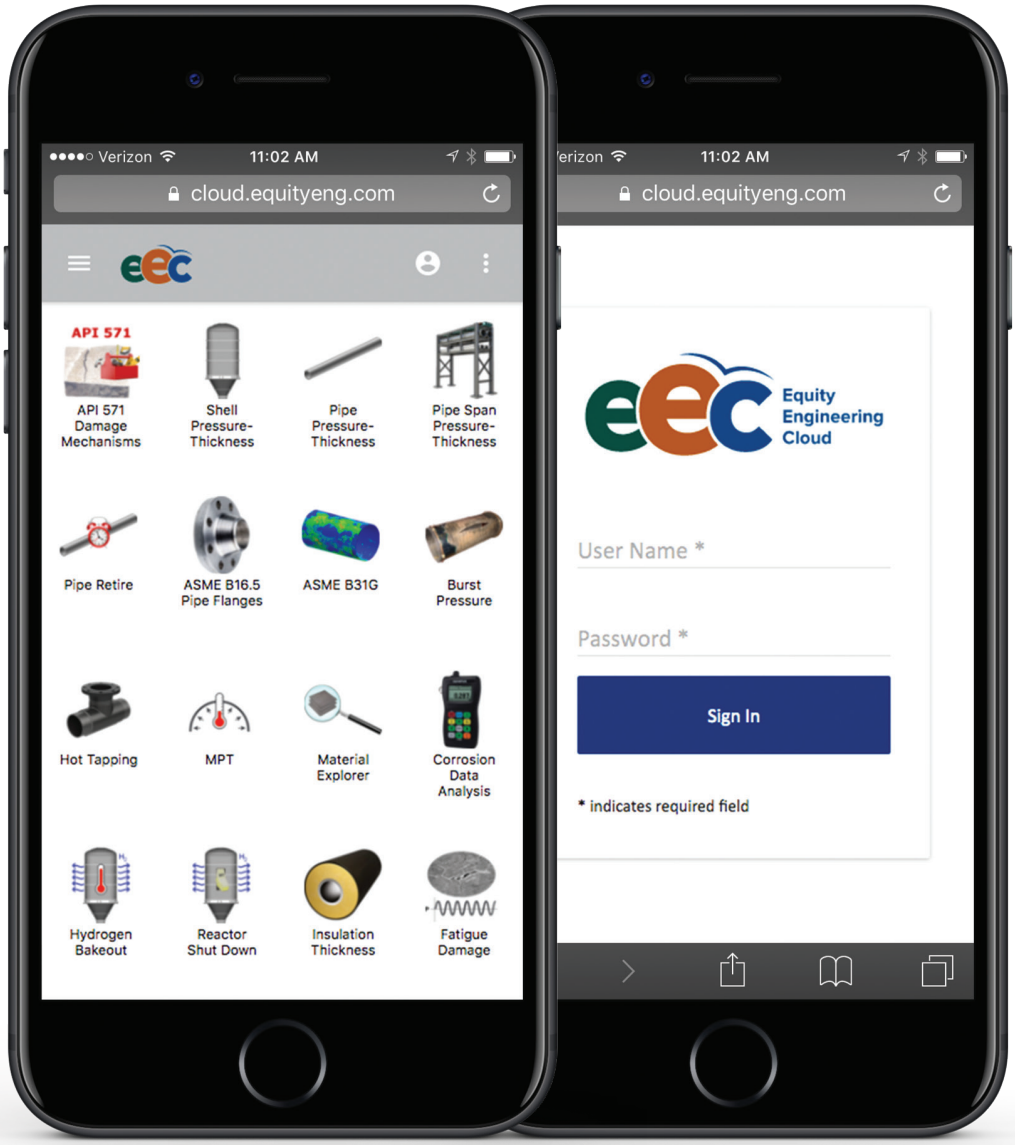

HTHA MODEL ADVANCEMENTS

The Equity Engineering Group, Inc.

APPLIED RESEARCH AND DEVELOPMENT

HTHA MODEL ADVANCEMENTS

BY: CHARLES PANZARELLA, PH.D

As described in the first edition of E²G Industry Insights, the Applied Research and Development group at E²G has already developed the most sophisticated model for predicting HTHA life to date, considering both volumetric and crack-like HTHA damage accumulation. These procedures were first developed during the work of the ongoing HTHA JIP, but progress has continued at a rapid pace since, and many improvements have been made. The time-dependent model accounts for many contributing factors to damage accumulation, such as variable operating conditions, the transient diffusion of hydrogen, kinetic rates of methane formation, non-ideal gas behavior, and stress effects including both primary and residual stresses. This model was shown to be fairly predictive and matched all the observed trends very well, including a prediction of the general shape and location of the Nelson curves that appear in API 941.

Since the initial model was developed, many new improvements have been made to the underlying methodology. Foremost among these are the inclusion of piping stresses, improved initial residual stress profiles, more accurate stress relaxation models, and the incorporation of new materials and improved property fits. Other component shapes such as spherical and conical have been added. New fracture toughness methods have been incorporated that account for different microstructures and methane content.

A further enhancement still under development is the incorporation of our HTHA damage model into commercial FEA codes such as Abaqus in order to perform more sophisticated Level 3 FFS assessments of complex shapes such as nozzle connections. This approach does away with some of the simplifying assumptions that are necessary for the simpler model that may lead to less accurate predictions.

Probabilistic methods have also been developed and used to predict the probability of failure (POF) over time rather than returning a single value of remaining life. This is a necessity due to the many uncertainties that are inherent in this problem. By properly accounting for uncertainty, more confidence can be given to life predictions and less conservative predictions can be made. This probabilistic approach is being used with certain simplifying assumptions to develop a generalized damage factor approach that can be easily incorporated into any Risk-Based Inspection (RBI) methodology. This is similar to how damage factors have been traditionally used for other failure modes, such as for thinning pipes with an uncertain corrosion rate.

The effect of inspection can also be included by incorporating what is known about the accuracy of currently available detection methods. E²G continues to develop enhanced methods in parallel with others in the industry, which can then be incorporated into the RBI methodology to provide a more accurate assessment of the value of an inspection versus its cost.

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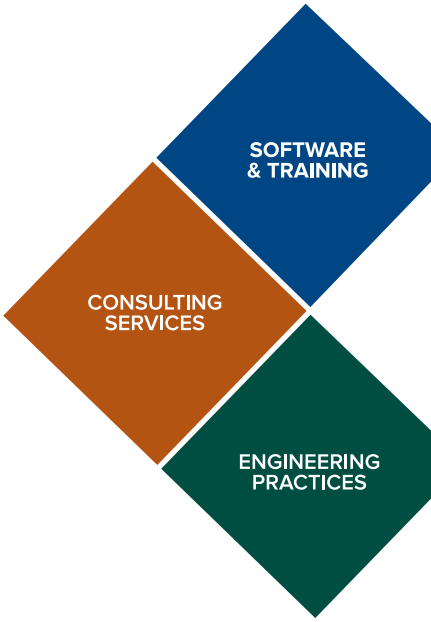

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