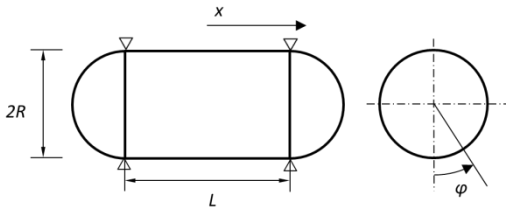
2014 V&V Challenge: Problem Summary

This handout provides a summary of the challenge problem - the goal is to allow the reader to follow workshop presentations. For the full problem statement, the code and data, and all other information about the workshop, visit the website: https://share.sandia.gov/vvcw/.

Backstory

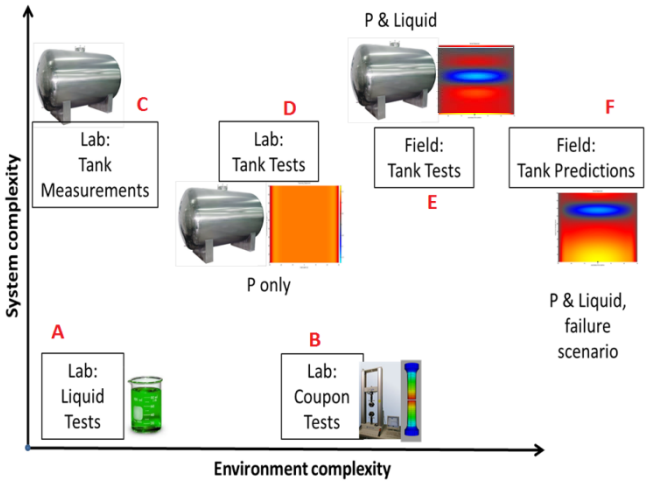
Side view and axial view of tanks



MysteryLiquid Co. maintains a large number of storage tanks that hold a Mystery Liquid under pressure. This loading causes deformation of the tank walls. During a standard safety inspection, measurements on one tank produced were out-of-spec when a large load was applied.

The out-of-spec tank and two neighboring tanks were taken out of service and underwent additional testing. In addition, four tanks from different locations each underwent a limited set of tests while still in service. The company has commissioned a modeling study to complement these experimental tests. The assumption is that the historical safety margin is being violated, and we need to better understand the margin to failure. The goal is to determine whether the remaining tanks can safely remain in service or if they must be retired immediately.

The Problem



(A) Mystery Liquid – known relationship between composition and specific weight

(B-E) Out of spec tank (T0) and two neighbors (T1, T2) are taken to a lab for tests. Four more tanks are tested while in service (T3-T6)

(B) T0 was used for material property tests – Young's modulus, Poisson's Ratio, Yield stress

(C) Tank dimensions are measured – radius and length from T1, T2 and wall thickness from T0

(B,C) Manufacturer gave specifications for dimensions and material properties (when tanks were new)

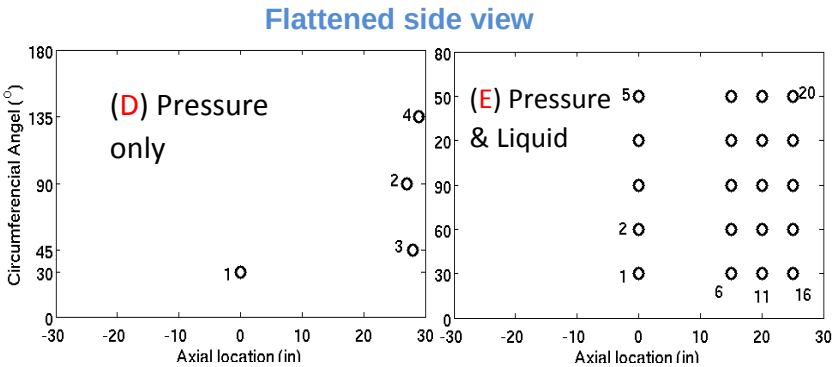
(D) T1, T2 were pressurized – displacements are measured at 4 locations (6 tests on each tank). In addition, a computational model is available to predict displacement and stress.

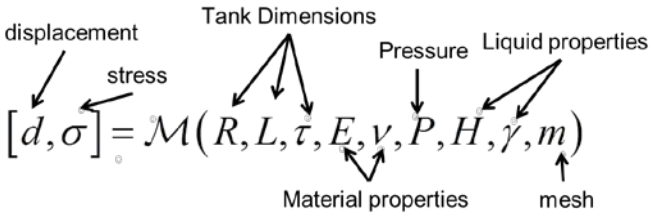
(E) T3-T6 were still in service with moderate pressure and liquid loads - displacements are measured at 20 locations (3 tests on each tank). The same model as in (D) can simulate response to this loading.

(F) A model will be used to predict failure at extreme pressure and liquid loading levels

The nominal loading information for each test is given (D, E), and displacements are measured at the locations shown to the right.

Loading (pressure, liquid height, and composition) can be controlled during tests, but not precisely. Also, displacements have significant measurement uncertainties, and stress cannot be measured on the tanks.





A model and code (represented in the equation to the left) are provided to compute displacement and stress at any location for any loading. Four meshes were created, at various levels of refinement. The predicted responses are known to vary with mesh resolution. Code verification is not possible with this problem. The model has clear limitations, most notably – it includes only the cylindrical section, with no end caps.

Data + Model Summary

The failure model comes from yield stress data (B). The tank is predicted to fail if computed stress in the walls exceeds the material's yield stress. Other dimensions and material properties come from manufacturer data and limited test data (A, B, C). Displacement measurements from the tanks are available under two types of loading conditions – pressure only (D) and both pressure and liquid (E). The model can predict tank wall displacements and stresses at any location for any loading, (D, E, F). This means that comparisons between model predictions and experimental data can be made at two conditions (D, E).

The Challenge

Based on the model and available data, develop and execute an analysis strategy to predict failure probabilities for two loading scenarios. Assess the credibility of the predictions, and make a recommendation of whether to retire the tanks.

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