Release Notes

Version 04.02.04

Table of Contents

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Installation

To install this new version of AFFTAC, version 04.02.04, follow the steps below:

1. Unzip the installation zip file.
2. Close all Windows applications.
3. Run setup.exe, taking note of the **installation directory**.
4. If you are an existing user, you may copy your database files (`*.db`) from the previous versions' installation folder to the new **installation directory**.

If you have problems or concerns e-mail srunnels@srconsult.com.

New features

1. The ability to simulate the effects that occur when insulation/thermal protection no longer fully covers the tank.

Modifications

1. Established additional surface temperatures for those regions where the insulation has fallen off.
2. Inserted lines to update those temperatures in the following routines:
    a. `WallTemperature` – for the shell full condition
    b. `SurfaceT` – solving the same type of equation solved previously, except now for both surface temperatures
3. Modified the heat conduction terms to represent heat flowing from both the insulated and non-insulated parts of the tank in the following routines:
    a. `WallTemperature` – modified `netq`
    b. `HeatIntoLiquid` – modified `htin`
    c. `ShellFull` – modified `htin`
4. Modified `UserInput` and `anlyrpt` to read the value for the fraction of the tank car still covered with insulation/thermal protection. This value is read from a new file called `input_aux`.
5. Modified `UpdateBurstStrength` to use the highest temperature among the following: The vapor wall temperature and the outside wall temperatures (adjacent to the liquid and vapor) where the insulation/thermal protection is missing.
6. Modified the GUI to accept percent coverage from the user for 5 of the 6 insulation/thermal protection systems (not for the bare tank option) and to write the file `input_aux`.
7. Modified the GUI to ensure backwards compatibility with older databases.

Testing

The following test cases are used to test the partial insulation/thermal protection coverage upgrade.

Extreme Values Tests

Test cases 6.1.1, 6.1.2, 6.1.3, 6.2, and 6.3 [1] are modified so that they all use the "Steel Jacketed" (Option 3) thermal protection system, with an initial conductance of 0.22 Btu/hr-ft^2 deg-F and a near-infinite interval for change (e.g., 999999 min for "Time interval for change"). However, the fraction of the tank covered by that system is set to zero. These cases are then renamed as follows:

6.1.1 → 1.1a
6.1.2 → 1.2a
6.1.3 → 1.3a
6.2 → 2a
6.3 → 3a

Duplicates of these cases are made, except the insulation system is changed so that it has an instantaneous decay time but 100% coverage of the tank. The test cases are named as follows:

6.1.1 → 1.1b
6.1.2 → 1.2b
6.1.3 → 1.3b
6.2 → 2b
6.3 → 3b

Since there should be no difference between an insulation that does not decay but also does not cover the tank at all and an insulation that decays instantly but covers the tank fully, the results for the "a" and "b" versions should be identical.

In a similar way, two more sets of test cases are developed and named as follows:

6.1.1 → 1.1c and 1.1d
6.1.2 → 1.2c and 1.2d
6.1.3 → 1.3c and 1.3d
6.2 → 2c and 2d
6.3 → 3c and 3d

The “c” cases use Option 5, “Temperature Dependent” thermal protection system with K1 = 0.017, K2 = 0.014, and K3 = 0.011. In case “c”, the coverage is set to zero and the thickness of the insulation is set to 1 inch. In case “d”, the “Bare Tank” option (Option 1) is chosen. The results should be the same.

The same test used above is also used for the temperature-independent (Option 4) system and the FRA-standard (Option 2) system.

Lastly, two more test case sets, “e” and “f” are created in an analogous way. Sets “e” use the 2-component Steel Jacketed system (Option 6) with zero coverage. Sets “f” use the Steel Jacketed system (Option 3) with 100% coverage, but with instantaneous decay (i.e., the “Time interval for change” is set to zero). These results should also be the same. Note: In testing version 04.02.04, the results are close but were not identical.

Contrived Values Test

A more rigorous test of the partial coverage capability requires the following modifications:

1. `SurfaceT` – At the end of the routine, artificially set $T_{outer\_liquid\_noSP} = T_{outer\_liquid}$ and $T_{outer\_vapor\_noSP} = T_{outer\_vapor}$.
2. `GetWallConductance` – Artificially set the composite conductivity for the liquid and vapor regions equal for both the bare tank case (Option 1) and the temperature-independent insulation case (Option 4).

Then, two versions “g” and “h” of the original test cases discussed above are created. Both use temperature-independent insulation (Option 4) with time-constant insulation. The parameters for Option 4 are obtained by making reference to Figure 1, with the modifications described above in mind. A unit of the tank is considered, wherein the outer surfaces of the insulated and non-insulated surfaces are forced to be the same temperature. A fraction F_i is covered by insulation with conductivity c_i. The tank conductivity is C_T, and is the same in the liquid and the vapor regions (again, via code modification). The heat flux q_i is

$$q_i = \frac{c_i c_T}{c_i + c_T} \Delta T F_i + c_T \Delta T (1 - F_i)$$

The heat fluxes for cases “g” and “h”, q_g and q_h, can be expressed using the above equation. Furthermore, by equating them and setting $c_h = Mc_g$, the following equation results:

$$F_h = F_g \left(\frac{Mc_g + c_T}{c_g + c_T} \right)$$

Next, M is arbitrarily chosen to be 10 and F_g to be 100%. The result is the following:

Case “g”: Constant conductivity of 54 BTU/hr-ft^2 deg F at 100% coverage
Case “h”: Constant conductivity of 5.4 BTU/hr-ft^2 deg F at 88% coverage

The results for these two sets of cases (1.1g, 1.2g, 1.3g, 2g and 3g and the corresponding “h” versions) should be identical. When run in AFFTAC, the results are close but not identical because of numerical aspects. Specifically, the higher conductivity used in case “h” requires a smaller time step. By reducing the time step from the original test cases, the results for “g” and “h” can be brought into acceptably close agreement.

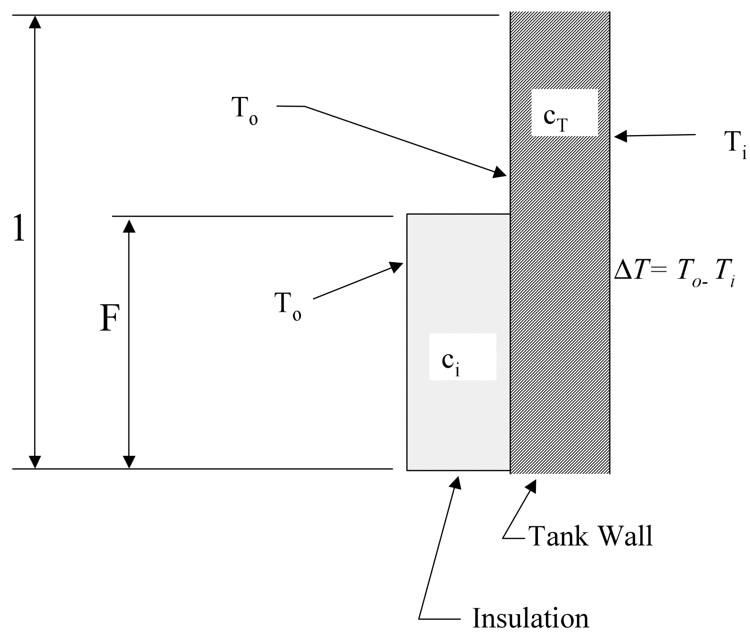

Figure 1: Contrived test case for testing partial coverage of insulation/thermal protection.

References

1. Johnson, Milton (IIT Research Institute, Chicago, IL 60616), *Tank Car Thermal Analysis, Volume I, User's Manual for Analysis Program (final report)*, for the U.S. Department of Transportation, Federal Railroad Administration, Office of Research and Development, Washington, D.C. 20590, DOT/FRA/ORD-98/09A, November 1998.