Water Tender Calibration Worksheet (version 1, November 2016)

Ohio Fire Chiefs' Association, Water Supply Technical Advisory Committee

Purpose:

This worksheet is designed to produce an estimate of expected continuous flow contribution (CFC) for an individual water tender under a given set of conditions. The concept is to create a performance profile for each apparatus, providing an estimate of its gallons per minute (gpm) contribution to a multi-apparatus water shuttle operation under a range of typical conditions. The resulting profile is designed to be maintained as a reference for each apparatus to assist in planning for water supply and mutual aid.

How To Use:

The worksheet is a Microsoft Excel file (.xlsx) with two tabs, one visible and one hidden. The user inputs the designated items in sections 1, 2, and 3 (the boxes highlighted in pink) of the visible tab. Once all items have been entered, the worksheet will automatically complete all calculations (via formulas on the hidden tab) to produce the performance estimates. The user may save or print the resulting profile as needed.

The user must complete the following items:

1. Unit Identification section

- Items 1a (Home Agency/Fire Department) and 1b (Unit Designator) are not mandatory, but are highly recommended because they will identify the apparatus.
- 1c. Apparatus Design: Clicking in this box will produce a pull-down menu. Select the appropriate water tender type (conventional/gravity or vacuum), and the worksheet will automatically populate the Residual Water Factor (k) field. This item represents the 10% penalty assessed against conventional tenders (per NFPA 1142) due to water in the tank that cannot be efficiently unloaded. The default value for "k" is 0.9. If you want to run the calculations without using this penalty, selecting "vacuum" will credit your apparatus for 100% of tank volume.

2. Apparatus Characteristics section

- 2a. Tank Volume: Provide the actual tank volume in gallons. This information may come from the manufacturer or be determined locally.
- 2b. Maximum Fill Rate: Provide the maximum rate at which the tank may be filled in gallons per minute (gpm). This figure may come from tank warranty information (normally 1000 gpm), through performance tests of the apparatus, or from other sources. The worksheet assumes that you will fill at the maximum rate for the apparatus. You may use lower numbers as well to account for known limitations of hydrants or assigned fill site engines.
- 2c. Average Dump Rate: Provide the average rate at which water will be unloaded from the apparatus in gallons per minute (gpm). This figure is usually determined from performance testing of the apparatus, but you may use any figure.

3. Water Handling Factors section

- 3a. Average Speeds for Estimates: Provide three average speeds to use in developing the estimates in miles per hour (mph). NFPA 1142 assumes an average speed of 35 mph for water shuttles, but you can use any three speeds you like. A reasonable set would be 25, 35 and 45 mph to estimate performance under a range of road conditions.
- 3b. Fill Site Handling Time: Enter the time in minutes needed to position the apparatus at the fill site and make all necessary hose connections to begin filling the tank. A well-drilled crew at a good site should be able to accomplish this in 0.5 minutes (30 seconds). Use a longer time to account for crew inexperience, a challenging fill site, or other factors.
- 3c. Dump Site Handling Time: Enter the time in minutes needed to position the apparatus at the dump site and begin unloading water into portable tanks. A well-drilled crew at a good site should be able to accomplish this in 0.5 minutes (30 seconds). Use a longer time to account for lack of skill, a poorly-designed dump site, or other factors.

Worksheet Outputs

Sections 4 and 5 provide estimates of the expected continuous flow contribution (CFC) that the apparatus will make to the water shuttle in gallons per minute (gpm). Section 4 provides estimates in a table for eight different shuttle route distances. Section 5 provides the same information as performance curves, which allow the user to interpolate the expected CFC for any route distance out to 25 miles (the limit of the model).

Underlying Calculations

All necessary CFC calculations are performed automatically on a hidden tab of the worksheet, requiring no user interaction after the mandatory data items are entered. The estimates are calculated using the following formulas:

1. Continuous Flow Contribution (CFC) calculation (gpm):

$$CFC = V/T$$

Where: V is effective tank volume (gallons); T is total shuttle time (minutes)

2. Effective Tank Volume (V) calculation (gallons):

$$V = VR \times k$$

Where: VR is nominal tank volume (gallons); k is the residual water coefficient (1.0 for vacuum tankers, 0.9 for conventional tankers)

3. Total Shuttle Time (T) calculation (minutes):

$$T = TD + TF + TR$$

Where: TD is dump site time (minutes); TF is fill site time (minutes); TR is route travel time (minutes)

4. Dump Site Time (TD) calculation (minutes):

$$TD = (V/RD) + HTD$$

Where: V is effective tank volume (gallons); RD is average dump rate (gallons per minute); HTD is dump site handling time (minutes)

5. Fill Site Time (TF) calculation (minutes):

$$TF = (V/RF) + HTF$$

Where: V is effective tank volume (gallons); RF is maximum fill rate (gallons per minute); HTF is fill site handling time (minutes)

6. Route Travel Time (TR) calculation (minutes):

$$TR = (60/RS) \times D$$

Where: RS is speed of travel along the route (miles per hour); D is total round trip distance of the route (miles)

This method is similar to, but not the same as, the one used in NFPA 1142 (Section C). This version allows greater customization to account for variations in travel speed, and handling time at the fill and dump sites. Initial test runs have shown that this method generates water tender performance estimates that compare favorably to actual performance test results.