SMA
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Evaporation Formula
February 1, 2018

The following formula has been derived from the Penman-Monteith equation, which is traditionally used as a standard of reference for evapotranspiration rates. This equation allows one to execute procedures for calculation of various parameters involved in the water use of several crops including the sum of evaporation and plant transpiration. This model not only had the lowest error but was the most applicable with the data that is available to us. In this modified equation, we are accounting for the several atmospheric factors that control rates of evaporation, such as temperature, windspeed, and humidity (pulled from NMSU Climate Center). This allows us to account for rate variation depending on the conditions in a specific region and time of year where conditions may render the traditional drip pan method impracticable or inaccurate. We were also able to isolate and remove the plant transpiration from the equation to allow it to be applicable to tank batteries, storage containers or facility polyuria liners. This derived equation was then back-calculated and tested against the U.S EPA Evaporation Equation, the Stiver and MacKay Evaporation Equation, and the original Penman-Monteith equation with less than 3% error. After reviewing several case studies on all the above equations, it was noted that our derived formula read slightly low and is used for shallow water and the EPA's Evaporation Equations reads slightly higher and meant for greater amounts of water. For this reason, we have decided to include both methods in our measurement to get acceptable range for total evaporative loss.

Assume Reference Weather Station Timeseries Data from NMSU's Climate Center.

(Choose the weather station network within a reasonable range of desired location)

https://weather.nmsu.edu/ziamet/

Derived Penman-Monteith (Low End)

$$(0.62 \text{ gal.} * \text{surface area ft}^2) - (A_m \text{ gal.} * \text{surface area ft}^2) = \text{evaporative loss gal/day}$$

Where 0.62 gal. is a constant

A_m in gal. is the rate of evaporation per specific containment and atmospheric parameters.

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US EPA Evaporative Equation (High End)

$$E = \frac{7.4PA(0.447W)^{0.78}}{T + 459.67}$$

Where E is the evaporative rate in gallons/day

A is the surface area in ft^2

W is the windspeed above the pool in mph

P is the water's vapor pressure at ambient temperature in mmHG

T is Temperature in F°

Using the surface area parameters provided by Mr. Asher and the climate data from January 29th, 2018, our Penman-Monteith equation calculated a 688.069 gallon/day loss while the EPA equation calculated a 1140.693 gallon/day loss. The actual measured loss taken in the field was 1/4 of an inch. When converted into gallons, it shows a measured loss of 971.85 gallons. As the missing water was between the calculated range, we have accounted for the loss of water to evaporation. If there would have been a higher measured loss than 1140 gallons, then there would be a higher potential for a leak.

Input Parameters from NMSU Climate Center (PM)	
Mean Temperature (C°)	5.95
Avg. Wind Speed (mph)	4.633
Surface Area (ft^2)	6270
Etr (inches)	0.177

Input Parameters from NMSU Climate Center (EPA)	
Surface Area (ft^2)	6270
Avg. Wind Speed (mph)	4.633
Vapor Pressure @ Ambient Temp. (mmHG)	7
Temperature (F°)	42.72

Measured Loss 1/4 of an inch on 1/29/18
971.85 gal./day

Equation Components	
Y	0.10974
A_m gal	0.51026

Evaporative Loss (gal./day) (LOW)
688.0698

Evaporative Loss (gal./day) (HIGH)
1140.693