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| CLIENT: | Client | PREPARED BY: | ME!, P.E. |
| PROJECT: | Cement Plant Water System | DATE: | June 7, 2023 |
| DESCRIPTION: | Estm. HGLs at "reservoir" for water model | | |
| PROJECT No.: | //job number// | | |

Mathcad Prime 5.0 worksheet prepared by ME!, P.E. //edited for posting on ENG-TIPS.COM//

## 1.0 WORKSHEET INTRODUCTION

The purpose of this worksheet is to convert water system pressures to hydraulic grade lines (HGLs) for the Reservoir in the EPANET model of the plant's water system.

## 2.0 PROJECT DESCRIPTION

The cement plant receives water for domestic uses and fire protection from the City of _____. For modeling the on-site water system, I chose the intersection of _____ Blvd. and _____ Blvd. as the "reservoir" that feeds the plant's water system and which regulates the HGLs in the model. This intersection, which is about 650 feet north of the entrance to the plant, is one of the locations for which fire flows were both tested and modeled for the City's yyyy Water Master Plan Update [1], and it is the junction of three 12-inch water mains.

## 3.0 CONVERSION FACTORS (FYI)

$$1\ ft \cdot \gamma_w = 0.433\ psi \qquad \frac{1\ psi}{\gamma_w} = 2.308\ ft$$

## 4.0 DATA

Unit weight of water: $\gamma_w \equiv 62.4\ pcf$ {1}

Ground elevation at "reservoir": $Elev := 15.0\ ft$ {2}

Excerpts from [1], Table #.#: {3}

Table [redacted] Fire Flow Calibration Results
[redacted] Water Master Plan Update
City of [redacted]

| Test Site | Test Location | Date/ Time | Hydrant Type | Hydrant ID | Field Measured Data[1] Hydrant Flow (gpm) | Field Measured Data[1] Hydrant Pressure (psi) Static | Field Measured Data[1] Hydrant Pressure (psi) Residual | Model Simulated Data Hydrant Pressure (psi) Static | Model Simulated Data Hydrant Pressure (psi) Residual |
|---|---|---|---|---|---|---|---|---|---|
| 11 | [redacted] Boulevard | [redacted] | Flowing | F18-09 | 942 | -- | -- | -- | -- |
| | and [redacted] | 12:51 PM | Pressure | F18-02 | -- | 62 | 61 | 60.8 | 57.5 |
| | Boulevard | | Pressure | F17-13 | -- | 64 | 61 | 60.8 | 57.7 |

Estimated Pressures at Test Site 11 per [2]: {4}

| $HydID$ | $P_{@1500\_gpm\_FF}$ $(psi)$ | $P_{@1750\_gpm\_FF}$ $(psi)$ | $P_{@2000\_gpm\_FF}$ $(psi)$ | $P_{@2250\_gpm\_FF}$ $(psi)$ |
|---|---|---|---|---|
| "F18−02_Field" | 59.5 | 59.0 | 58.0 | 57.0 |
| "F17−13_Field" | 57.0 | 54.5 | 52.0 | 49.0 |
| "F18−02_Model" | 53.0 | 50.5 | 48.0 | 45.0 |
| "F17−13_Model" | 53.0 | 50.5 | 48.0 | 45.0 |

For the EPANET model, I split the difference between "F17−13_Field" and "F17−13_Model" (see next page). {5}

Pressures to convert:

| Analysis Condition | Fire Flow | Estm Pressure |
|---|---|---|
| $AC$ | $Q$ $(gpm)$ | $P$ $(psi)$ |
| "PDH" | 0 | 60.0 |
| "MDD+FF" | 1500 | 55.0 |
| "MDD+FF" | 1750 | 52.5 |
| "MDD+FF" | 2000 | 50.0 |
| "MDD+FF" | 2250 | 47.0 |

{6}

## 5.0 CALCULATIONS

Hydraulic grade lines:

$$HGL := Elev + \frac{P}{\gamma_w} \quad \{7\}$$

Results:

$$Q = \begin{bmatrix} 0 \\ 1500 \\ 1750 \\ 2000 \\ 2250 \end{bmatrix} gpm \quad P = \begin{bmatrix} 60.0 \\ 55.0 \\ 52.5 \\ 50.0 \\ 47.0 \end{bmatrix} psi \quad HGL = \begin{bmatrix} 153.5 \\ 141.9 \\ 136.2 \\ 130.4 \\ 123.5 \end{bmatrix} ft \quad HGL_{USE} := \begin{bmatrix} 153.0 \\ 142.0 \\ 136.0 \\ 130.0 \\ 123.0 \end{bmatrix} ft \quad \{8\}$$

## A. REFERENCES

[1] _____, "City of _____, yyyy Water Master Plan Update," [date].
[2] hosemaster.com/resources/hydrant-flow-test-calculator

## B. NOTES

{1} The most commonly used unit weight for water is $62.4\ pcf$ and it occurs at a temperature of $58.5\ °F$. The temperature of water in buried pipelines in temperate climates is often cited as being about $60\ °F$ and this is close enough to justify using $62.4\ pcf$ here. At $40\ °F$, the specific weight of water is $62.43\ pcf$; at $68\ °F$ (a commonly used standard temperature), the value is $62.31\ pcf$.
{2} I estimated the ground elevation of the subject intersection using Google Earth. Google Earth produced an elevation closer to the site survey provided by the client than did the yyyy and yyyy USGS "_____ Quadrangle" maps that cover the site. The USGS maps have very sparse elevation information in the vicinity of the site and I considered them to be poor choices for this task.
{3} Excerpts from [1], Table #.#. Test Site 11 is the "reservoir" for the EPANET model of the plant's on-site water system.
{4} Use [2] and the data in [1], Table #.#, to estimate the pressures at Test Site 11 when providing different fire flows to the plant. Estimates are rounded to the nearest $0.5\ psi$. The $2000\ gpm$ and $2250\ gpm$ fire flows are included for modeling the future system in case the City increases the fire flow requirement. Preliminary model runs show that the maximum fire flow that the combined City-plant water system can deliver is approximately $2750\ gpm$. Any higher and additional improvements to either or both systems would be required.
{5} _____ made and used a skeletonized model of the City's water distribution system for the Water Master Plan Update. Skeletonized models are conservative because even small-diameter looped pipes add to system capacity. For this project, I consider the field measurements to be more representative of the system. However, to be conservative and to approximately account for the small amount of domestic water that I did not include with the fire flow amounts, I split the difference between estimated pressures for "F17−13_Field" and estimated pressures for "F17−13_Model".
{6} The estimated pressure for "PDH" is based on typical pressures mentioned in [1].
{7} This formula is a subset of Bernoulli's Equation.
{8} Convert pressures to HLGs, then round off the results for use in the EPANET model.