Problem of the Day

2015.Aug.14

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A 14-inch diameter force main flows full. The lift station pump discharging to the force main pumps 650 gpm. It is 1.8 miles from the lift station to the discharge point. Flow into the lift station's wet well averages 612,000 gpd. Compare the volume of the force main with the average volume pumped by the lift station each day.

Introduction

This is the last in a series of Problems of the Day looking at the operation of a lift station discharging to a force main. This is a straightforward volume calculation. Once the volume of the force main is calculated, it will be compared to the 612,000 gallons of sewage pumped by the lift station each day.

Solution

The problem statement gives the following information in units used by WWTT:

1. Pipe diameter, d = 14 in
2. Pipe flowing full (since force mains, by definition, flow under pressure, they will always be flowing full)
3. Pipe length = 1.8 mi
4. Daily volume pumped = 612,000 gal

The question asks to find the volume in the force main. Since we will be comparing it to the volume, gal, pumped each day by the lift station, we will calculate volume in gal. These units are put between heavy vertical lines, as always, followed by an equals sign and the blank solution bridge.

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$$\left| \text{gal} \right| = \frac{\qquad}{\qquad}$$

Volume of a pipe is calculated the same way as the volume of a cylindrical tank, area of the circle times, in this case, length.

$$\left| \text{gal} \right| = \frac{0.785 \mid 14\ \text{in} \mid 14\ \text{in} \mid 1.8\ \text{mi} \mid}{\qquad}$$

Inches are then converted to feet, canceling unwanted units.

$$\left| \text{gal} \right| = \frac{0.785 \mid 14\ \cancel{\text{in}} \mid 14\ \cancel{\text{in}} \mid 1.8\ \text{mi} \mid \text{ft} \mid \text{ft} \mid}{12\ \cancel{\text{in}} \mid 12\ \cancel{\text{in}} \mid}$$

Miles are converted to feet, canceling unwanted units.

$$\left| \text{gal} \right| = \frac{0.785 \mid 14\ \cancel{\text{in}} \mid 14\ \cancel{\text{in}} \mid 1.8\ \cancel{\text{mi}} \mid \text{ft} \mid \text{ft} \mid 5{,}280\ \text{ft} \mid}{12\ \cancel{\text{in}} \mid 12\ \cancel{\text{in}} \mid \cancel{\text{mi}} \mid}$$

Finally, ft^3 (ft x ft x ft) are converted to gal, canceling unwanted units.

$$\left| \text{gal} \right| = \frac{0.785 \mid 14\ \cancel{\text{in}} \mid 14\ \cancel{\text{in}} \mid 1.8\ \cancel{\text{mi}} \mid \text{ft} \mid \text{ft} \mid 5{,}280\ \text{ft} \mid 7.48\ \text{gal} \mid}{12\ \cancel{\text{in}} \mid 12\ \cancel{\text{in}} \mid \cancel{\text{mi}} \mid \cancel{\text{ft}}^3 \mid}$$

Since all the unwanted units have now canceled and only the units needed in the answer remain (**gal**), we know the solution bridge is complete. The arithmetic gives the answer.

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$$\text{gal} = \frac{0.785 \;\; 14\ \cancel{\text{in}} \;\; 14\ \cancel{\text{in}} \;\; 1.8\ \cancel{\text{mi}} \;\; \cancel{\text{ft}} \;\; \cancel{\text{ft}} \;\; 5{,}280\ \cancel{\text{ft}} \;\; 7.48\ \text{gal}}{12\ \cancel{\text{in}} \;\; 12\ \cancel{\text{in}} \;\; \cancel{\text{mi}} \;\; \cancel{\text{ft}^3}}$$

0.785 x 14 x 14 x 1.8 x 5,280 x 7.48 ÷ 12 ÷ 12 = **75,958 gal**.

The total volume pumped by the lift station each day is 612,000 gal. The force main, then, holds about 12.4% (75,958 ÷ 612,000 = 0.124) of the total volume pumped each day.

Discussion

It would seem from the calculations in this series that the force main is too big. Obviously, nothing can be done about the length of the force main since the pump station can't be moved. But the choice of a 14-inch diameter pipe may have not been prudent. Perhaps the engineer calculated the need for a 14-inch diameter pipe based on a future flow, maybe a second lift pump, that has not yet materialized. Operators run into this kind of situation all the time. In this case, the collection system and treatment plant operators are likely having to deal with septic sewage coming out of the force main. Corrosion issues and odors at the exit of the force main are potential problems resulting from the septic sewage.

Happy calculating! Let us know, by leaving a comment, if you want us to do a specific problem, if you see a mistake, or if you have a question on any of the Problems of the Day you are looking at.