

## Lecture 20

### Emitter Selection & Design

#### I. Introduction

- There are hundreds of models, sizes and types of emitters, sprayers, bubblers, and others, available from dozens of manufacturers
- Prices of emitters can change frequently
- Some emitters have longer life than others, but cost more
- Some emitters have better pressure compensating features, but cost more
- Some emitters have better flushing capabilities, but cost more
- It is very difficult to know which is the “correct” emitter for a particular design, and usually there are a number of emitters that could work and would be acceptable for a given system
- Thus, the selection of an emitter involves knowledge of the different types, their prices, their availability, and their performance
- Experience on the designer’s part is valuable, and emitter selection will often involve a process of elimination

#### II. Long-Path Emitters

- So-called “spaghetti” tubing is a typical example of a long-path emitter
- Long-path emitters also come in spiral configurations (Fig. 20.1 of the textbook)
- These can be represented by an equation used for capillary flow under laminar conditions:

$$l_c = \frac{g \pi D^4 H}{\nu q K} \quad (372)$$

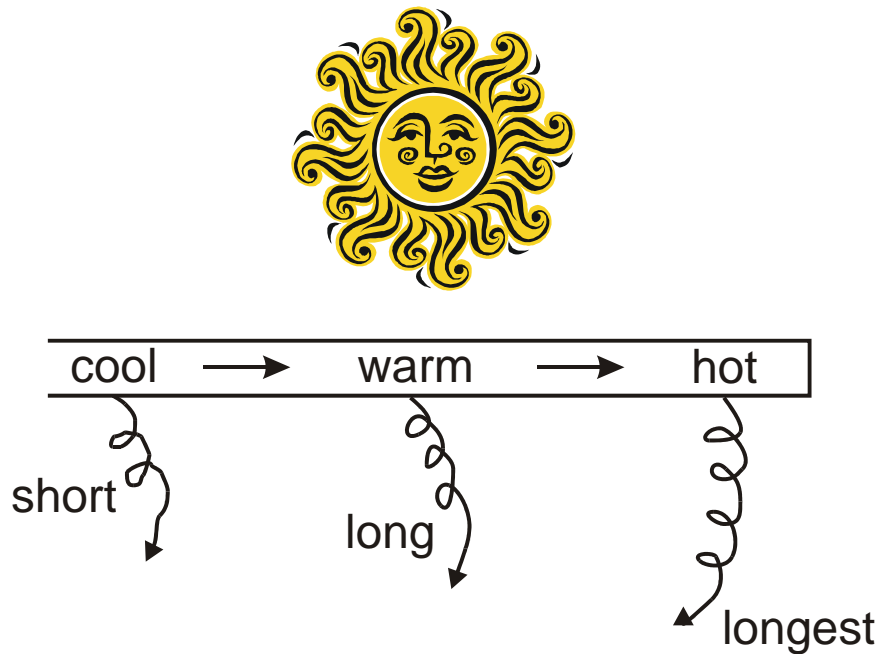
where  $l_c$  is the length of the flow path;  $D$  is the inside diameter;  $H$  is the pressure head;  $\nu$  is the kinematic viscosity (a function of water temperature);  $q$  is the flow rate;  $K$  is for units conversion; and  $g$  is the ratio of force to mass

- The above equation is only approximately correct for long-path emitters
- The above equation is based on circular cross-sections, which is typical
- The above equation assumes laminar flow, which may not be the case
- Note that the flow rate is proportional to the fourth power of the diameter, so the diameter is a very important dimension
- Note also that the flow rate is inversely proportional to the length (double the length and get half the flow rate)

- When is it valid to assume laminar flow? Consider that a Reynolds number of 4,000 is probably as high as you can go without transitioning from laminar to turbulent flow:

$$\frac{VD}{\nu} = \frac{4Q}{\pi \nu D} < 4,000 \quad (373)$$

or,  $Q < 15D$  @ 10°C, with Q in lph and D in mm



- In black PE lateral hose, sunlight warms the water significantly as the velocity slows down, and water viscosity decreases
- Long-path emitters would ideally be progressively longer along the lateral to compensate and provide a more uniform discharge along the lateral

### III. Tortuous- and Short-Path Emitters

- Tortuous-path emitters also have long paths, but not laminar flow. This is because the path has many sharp bends, and is in the form of a maze
- Tortuous-path emitters tend to behave hydraulically like orifices, and so do many short-path emitters
- Flow rate is nearly independent of the viscosity, at least over typical ranges in viscosity
- Many short-path emitters have pressure compensating features

#### IV. Orifice Emitters

- Many drip emitters and sprayers behave as orifices
- The orifice(s) are designed to dissipate energy and reduce the flow rate to an acceptable value
- Flow rate is approximately proportional to the square root of the pressure

#### V. Line Source Tubing

- Single-chamber tubing provides less uniformity than dual-chamber tubing
- In dual-chamber tubing, much of the head loss occurs through the orifices between the two chambers. The outer chamber is somewhat analogous to a manifold or header.
- The flow rate equation for dual-chamber tubing can be expressed as:

$$q = a'K \sqrt{\frac{2gHn_o^2}{(1+n_o^2)}} \quad (374)$$

where  $a'$  is the area of the outer orifice;  $K$  is an empirical coefficient;  $H$  is the pressure head; and  $n_o$  is the number of outer orifices per inner orifice ( $n_o > 1.0$ )

- See Fig. 20.2 in the textbook

#### VI. Vortex and Sprayer Emitters

- Vortex emitters have a whirlpool effect in which the water must exit through the center of the whirlpool
- Energy is dissipated by the friction from spinning in a chamber, and from exiting through an orifice in the center
- As mentioned in a previous lecture, the exponent on the pressure head is approximately equal to 0.4 (in the discharge equation). Thus, these can usually be considered to be (partially) pressure compensating

#### VII. Pressure Compensating Emitters

- Pressure compensating emitters usually have some flexible or moving parts
- These types of emitters tend to need replacement or repair more often than most of the simpler emitter designs, therefore incurring higher maintenance cost
- Figure 20.3 of the textbook shows one design approach for a pressure compensating emitter

- As defined previously, pressure compensating emitters always have a pressure head exponent of less than 0.5 (otherwise they aren't considered to be pressure compensating)

## VIII. Self-Flushing Emitters

- In this category there are *continuous* and *periodic* flushing emitters
- Periodic flushing emitters perform their self cleaning when the lateral is filled (before it reaches full operating pressure), and when the lateral is emptied. In other words, they typically flush once per day.
- Continuous-flushing emitters have flexible parts that can stretch to allow solid particles to pass through
- Fig. 20.4 in the textbook shows an example of one such design
- These can be sensitive to temperature changes and are not normally pressure compensating

## IX. Calculating the Discharge Exponent

- You can calculate the exponent,  $x$ , based on a pair of measured flow rates and pressure heads
- Recall a rule of logarithms:  $\log(a^x) = x(\log a)$
- The solution can be obtained graphically, but is more quickly accomplished with calculators and electronic spreadsheets
- If you have more than two pairs of  $q$  and  $H$ , then you can take the logarithmic transformation of the equation and perform linear regression; however, the regression will be mathematically biased toward the smaller values

## Design Approach & Example

### I. Review of Example Designs

- We will review example designs in Chapter 21 of the textbook, and discuss design alternatives and parameters affecting efficiency, etc

### II. Summarized Trickle Irrigation Design Process

- These are 15 basic steps, following the material presented in Chapters 17-24 of the textbook, that can be followed for the design of many trickle systems
  - These are basic steps and represent a summary of the generalized design process, but remember that each design situation will have some unique features
1. Collect data on the crop, climate, soil, topography, and irrigation water quality, field shape & size, water availability.

2. Select an emitter and determine an emission point layout such that  $33\% < P_w < 67\%$ . This will determine the number of emitters per plant,  $N_p$ . Emitter selection may involve field testing to determine the wetted width (or diameter),  $w$ .
3. Calculate  $d_x$ ,  $f_x$ , and  $T_d$ . Note that  $f_x$  will almost always be greater than 1.0.
4. Select a target value for EU (usually 70-95%; see Table 20.3) and estimate the peak-use transmission ratio,  $T_r$  (usually 1.00-1.10; see Table 19.3).
5. Calculate the leaching requirement,  $LR_t$ , based on crop type and irrigation water quality.
6. Let  $f = 1$  day (usually), then  $d_n = T_d$ . Calculate the gross application depth,  $d$ .
7. Calculate the gross volume of water required per plant per day,  $G$ .

$$G = K \left( \frac{d S_p S_r}{f} \right) \quad (375)$$

8. Calculate the daily hours of operation,  $T_a$ , (per station, or subunit) during the peak-use period.

$$T_a = \frac{G}{N_p q_a} \quad (376)$$

9. Determine the number of operation stations based on  $T_a$  (with more stations, the system capacity is lower).

If  $T_a = 24$  hrs, then  $N_s = 1$

If  $T_a = 12$  hrs, then  $N_s = 1$  or 2

If  $T_a = 8$  hrs, then  $N_s = 2$  or 3, and so on

10. Adjust  $N_p$  and  $q_a$  so that  $T_a N_s$  is equal to, or slightly less than, 90% (24 hrs/day) = 21.6 hrs/day. First, try adjusting  $q_a$  because this is usually less expensive than increasing  $N_p$ . If the emitter is pressure compensating, or if  $q_a$  must be greatly altered, you may need to change  $N_p$  (or you may need to select a different emitter).
11. Having determined the value of  $q_a$ , calculate the minimum allowable emitter discharge,  $q_n$

$$q_n = \frac{q_a EU}{100(1.0 - 1.27 v_s)} \quad (377)$$

*Note that if EU is high and  $v_s$  is high, it could be that  $q_n > q_a$  (but this would not be a reasonable calculation result!)*

12. Calculate the average (nominal) and minimum lateral pressure heads

$$h = \left( \frac{q}{K_d} \right)^{1/x} \quad (378)$$

$$h_n = h_a \left( \frac{q_n}{q_a} \right)^{1/x} \quad (379)$$

13. Calculate the allowable change in pressure head in an operating station

$$\Delta H_s = 2.5(h_a - h_n) \quad (380)$$

14. Calculate  $Q_s$ ,  $V_s$ , and  $O_t$ .

15. Finally, size the laterals, headers, manifolds and mainline(s) according to hydraulic design criteria.