Drip/Micro Irrigation: An Overview

Drip and Micro Sprinkler Irrigation Meeting

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Center for Irrigation Technology

California State University, Fresno

Center for Irrigation Technology...

- Irrigation Equipment Laboratory Testing
- Applied Research
- Analytical Studies and Special Projects
- Education
- A part of:

  Jordan College of Agricultural Sciences and Technology,

  California State University at Fresno

Ag Pumping Efficiency Program…

- In operation since 2002
- 100+ seminars across state
- 16,000+ pump efficiency tests
- 834 installed pump retrofit projects
- $2,611,000 in incentives paid
- 43,592,000 kWh saved in 1st year after retrofit

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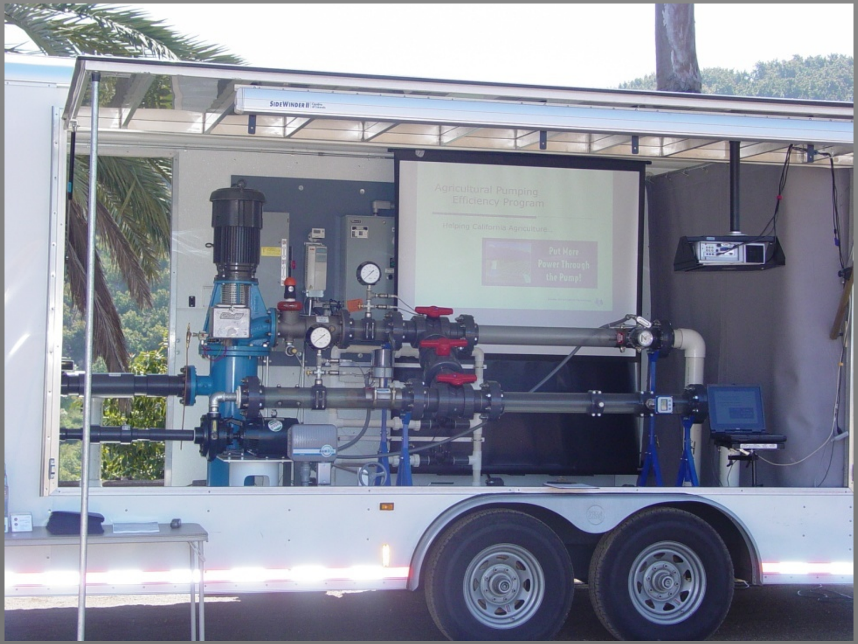
Mobile Education Center…

Visit Bill Green outside to learn how to reduce your irrigation pumping costs!



Today's discussion…

Drip/Micro Irrigation Systems

- Physical Characteristics
- Operating Characteristics
- Advantages
- Disadvantages
- Scheduling Irrigations

This is Drip Irrigation…

This is Micro-Spray Irrigation…

Physical Characteristics...

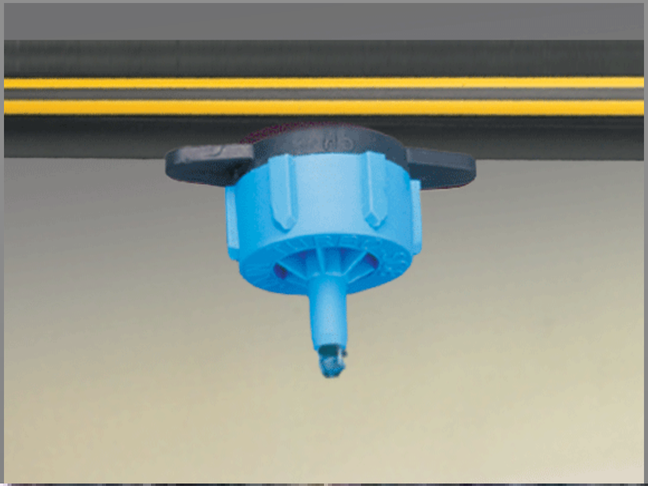
Water is delivered:

- Through an extensive system of above and below ground pipe
- To a specific point or area of the field
- For emission through specialized devices
- Pressure varies depending on terrain but emission devices operate 10-20 psi
- Requires some type of filtration

Emission Devices…

- **Point Source – standard emitters**
  - .5 – 2 gph per outlet
  - Can be integrated into the tubing during manufacturing process (inline) or installed in the field (online)
  - One or more emitters per plant
    - Spaced along drip hose at repeating spacing
  - Water spreads from a central point at the surface resulting in “onion” of wetted root zone
  - Double line drip is common in areas with sustained winds, instead of sprays (no wind drift and spray loss)

Point Source Emitters...



Emission Devices…

- Line Source – drip tape/row crop drip
  - Closely spaced emitters
  - Integrated within piping material during manufacturing
    - Flat tape
    - Round heavy wall tubing
  - Intended to produce a wetted strip of soil down the row
    - Process tomatoes, other vegetables
    - Cotton

Row Crop Drip…

Emission Devices...

Jets/Foggers/Micro-Sprinklers

- Water sprayed over larger surface area but generally not intended to overlap patterns
- Flow rates from 2-15 gph
- Used:
  - where more wetted root zone is desired
  - with a light soil that will not spread water (possibly economic tradeoff between multiple point sources or single sprayer)
  - Generally easier to check for correct operation than drip
  - Can provide limited frost protection

Spray Devices...

Jets

Micro Sprinklers

Foggers

Operating Characteristics…

- Evaporation losses generally low but can be quite high with jets due to combination of high frequency irrigation and substantial wetted surface area vs drip
- Infiltration during an irrigation is due to application rate and set time assuming that the application rate is less than the soil's infiltration rate at all times during the irrigation (*infiltration decreases over time*)
- Usually maintain low soil moisture depletions high soil moisture levels, leads to optimum growing environment and high yields for crops (*e.g. daily irrigation events during peak ET*)

Operating Characteristics…

- Requires extensive filtration and usually chemical additives to keep system clean (*continual or periodic*)

- Requires a stable (flow rate) and flexible (timing) water supply
  - Engineered system for specific flow rate
  - Usually irrigating frequently – thus, need a flexible water supply
  - Set times can vary throughout the season - thus, need a flexible water supply

Advantages…

- Very good for fertigation as precise control of application and placement is characteristic of system
- Doesn't wet the crop – less disease problems
- Good on streaked or variable soils
  (*as long as Application Rate < Infiltration Rate*)

Advantages…

- **May be necessary in rolling terrain**
- **Consistently high soil moisture is good for use with salty water- although micro irrigation does not get you out of the salt problem (*salts still need to be managed in soil profile*)**
- **Typically no or limited wind problems (*even with jets and mini-sprinklers, since there is no overlap to worry about – watch evaporation and extreme and constant winds*)**

Advantages...

- Good control of total application (*turn pump on, turn it off, known Application Rate*)
- Total labor costs can be higher or lower depending on maintenance but usually lower
- Given good design and maintenance, fairly easy to get good DU / IE (*Common solution to limited water supply and/or flow rate situations if the crop value will support the cost of the system*)

Advantages…

- Relatively easy to measure DU
- DU = device uniformity x field pressure uniformity (*Pressure compensating devices can overcome changes in PSI*)
- Device
  - Do not mix and match emission devices (*flow rate*)
  - No partial or completed plugged emitters!
- Pressure – It is critical to maintain design pressure and flow conditions in the field (*check pump performance and filters*)

Disadvantages...

- Usually most expensive system option
- Maintenance (*failure to maintain usually means system failure*)
- Restricted root zone (*not all soil volume wetted*) - can put crop at risk quickly if there is a system failure or break in water supply
- Irrigation management is critical

Disadvantages…

- Rodent/insect damage can be a problem
- Requires informed (*proactive*) management for maintenance and irrigation scheduling
- Frequent field checking and pressure/flow measurement is recommended

Economics of Design/Operation…

- **Capital Costs vs. Operating Costs – know the total lifetime costs of ownership**
- **Reduced capital cost may result in higher operating costs**
  (*selecting first cost option or low bidder*)
  - **Lower distribution uniformity – more water to buy and apply**
  - **Higher energy costs**

Economics of Design / Operation...

- Vineyard with 2 inch net water requirements
- 3% evaporation losses
- Water at $75/AF at pump
- Electricity at $.12/kWh (melded energy and demand costs)
- Low cost system with 83% DU and 194 kWh/AF (45 psi @ 55% pumping efficiency)
- Higher cost system with 90% DU and 163 kWh/AF (38 psi @ 55% pumping efficiency)

Economics of Design / Operation...

- Lower capital cost system
  - 22 inches / .83 = 26.5 gross applied
  - 26.5 / .97 = 27.3 gross with evap losses
  - Cost per acre-foot = $75 + .12 x 194 = $98.28/AF
  - COST PER ACRE/YR = $223.59

- Higher capital cost system
  - 22 inches / .90 = 24.4 gross applied
  - 25.3 / .97 = 25.2 gross with evaporation losses
  - Cost per acre-foot = $75 + .12 x 163 = $94.56/AF
  - COST PER ACRE/YR = $198.58

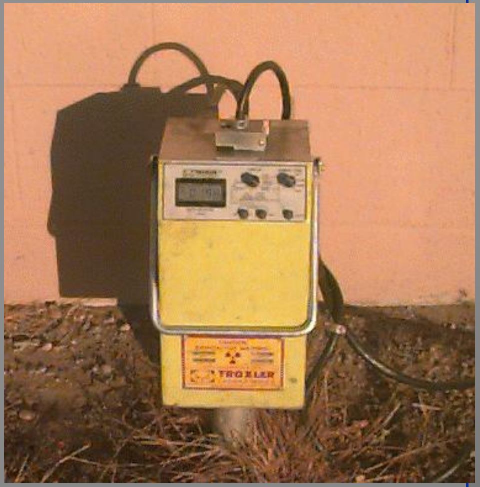
Scheduling Irrigations…

- Expensive system is intended to save water, fertilizer, labor, and/or increase yield/quality
- Important to take full advantage of the system capabilities for crop production
- Drip/Micro is inherently <u>uniform</u> (assuming good design/maintenance) – **NOT necessarily <u>efficient</u>**

Management Strategy...

- Decide WHEN to irrigate – but drip/micro is generally a high frequency system since intent is to maintain optimum soil moisture
- Determine HOW MUCH and WHEN to apply
- React to soil/plant moisture measurements

Soil moisture devices...



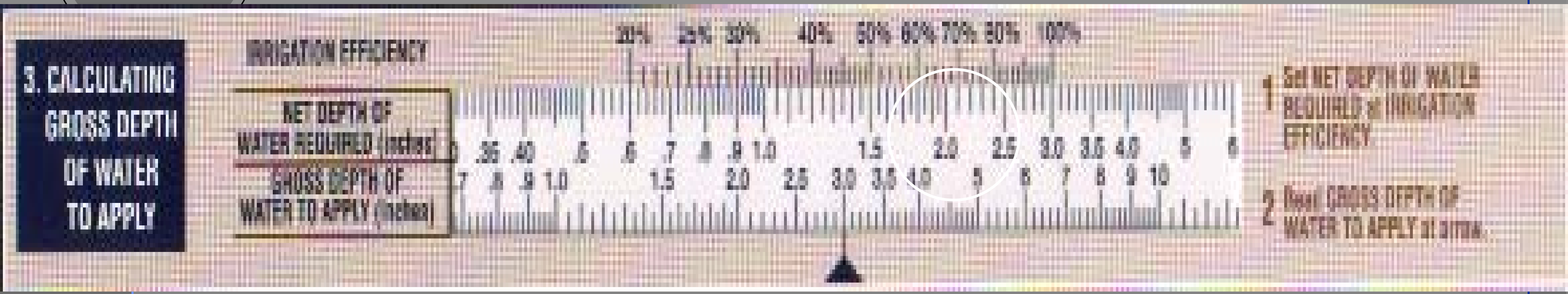
HOW MUCH to apply (length of set)...

- Know the application rate per plant in GPH
- Know the area per plant in Square Feet
- Know crop water use (ETc) since last irrigation
- Have an estimate of overall Irrigation Efficiency – DU, adjust for leaks, scheduling errors (*check periodically to verify*)

Calculating The Gross Depth of Water to Apply

- Gross = NET/IRR-EFF
- Where:
  - Gross = gross water application required
  - Net = water required by the crop
  - IRR-EFF = irrigation efficiency as a decimal (0-1.0)
- Note: This is based on individual field irrigation efficiency

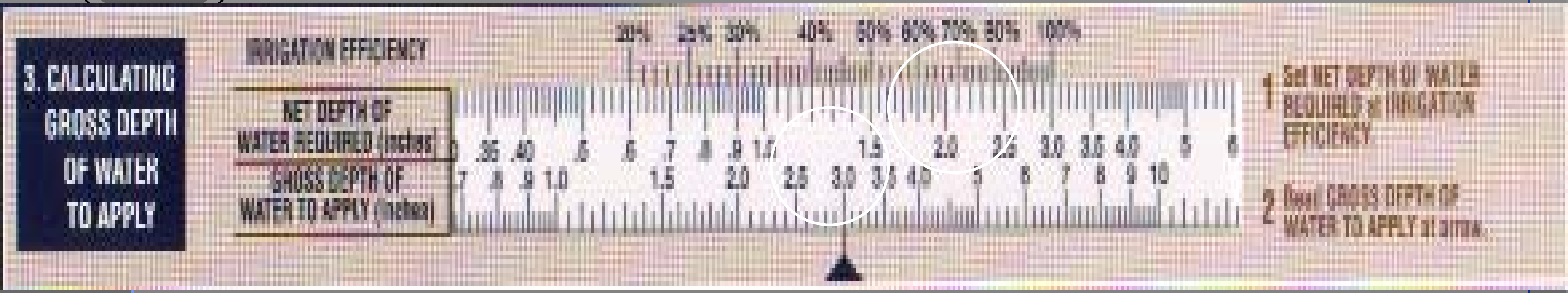
Calculating The Gross Depth of Water to Apply



- **Set the NET DEPTH OF WATER REQUIRED = 2.1 in**

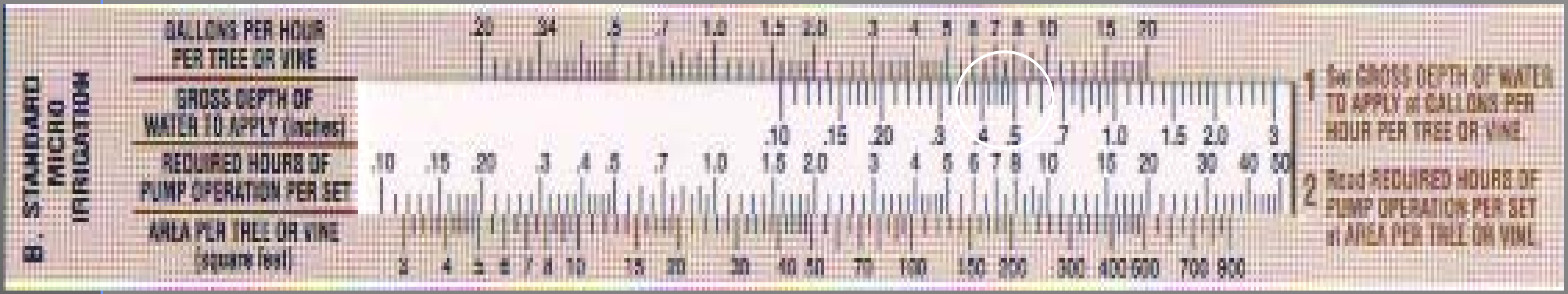
  IRRIGATION EFFICIENCY = 70%

Calculating The Gross Depth of Water to Apply



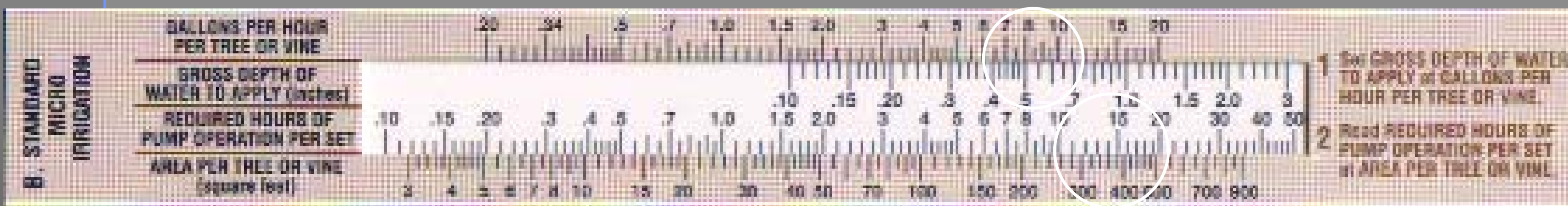
- **Set the NET DEPTH OF WATER REQUIRED = 2.1 in IRRIGATION EFFICIENCY = 70%**
- **Read GROSS DEPTH OF WATER TO APPLY at the arrow (3 inches).**

Standard Micro Irrigation



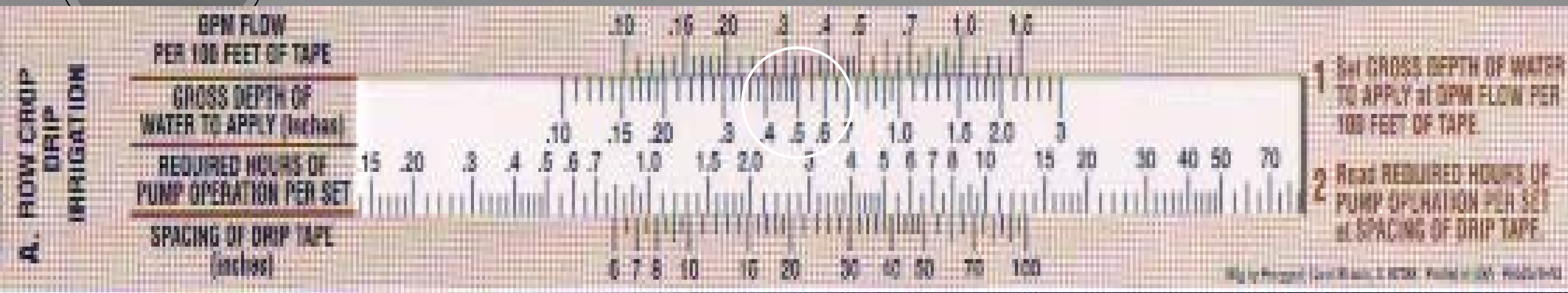
- **Set the GROSS DEPTH OF WATER TO APPLY = .5 in**
  GALLONS PER HOUR PER TREE/VINE = 8 gph

Standard Micro Irrigation



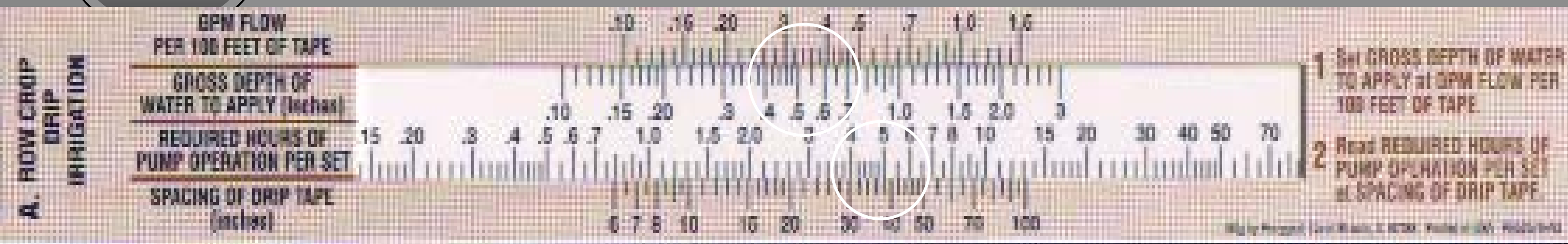
- **Set the GROSS DEPTH OF WATER TO APPLY = .5 in GALLONS PER HOUR PER TREE/VINE = 8 gph**
- **Read the REQUIRED HOURS OF PUMP OPERATION PER SET (14 hours) above the AREA PER TREE/VINE = 360 sq ft per tree/vine**

Row Crop Drip Irrigation



- **Set the GROSS DEPTH OF WATER TO APPLY = .5 in GALLONS PER MINUTE PER 100' of TAPE = .33 gpm/100'**

Row Crop Drip Irrigation



- Set the GROSS DEPTH OF WATER TO APPLY = .5 in GALLONS PER MINUTE PER 100’ of TAPE = .33 gpm/100’
- Read the REQUIRED HOURS OF PUMP OPERATION PER SET (5.25 hours/set) above the DRIP TAPE SPACING = 40 inches

Purchasing a Drip/Micro Irrigation System

A. System design philosophy

a) Common local practices
b) Economic limitations
c) Land and water limiting
d) Land tenure (lease/rent/own)
e) Service requirements (parts/warrenty)
f) Tax implications

B. System design options

a) Direct copy of neighbors
  - ✓ Good with the bad

b) Grower design
  - ✓ May lack full appreciation of economics

c) Dealer design
  - ✓ Practical design

d) Consultant design
  - ✓ Permits competitive bidding

C. Background information

a) Crops- present and future
b) Water supply-quantity/quality
c) Soils- texture/structure
d) Terrain- slope
e) Climate- ETo, wind, temperature
f) Hydrogeology- water table, drainage
g) Fertilization practices- injection, backflow
h) Cultural practices
i) Pest problems
j) Theft and vandalism

D. System Installation

- **Grower**
  - a) Broad technical capabilities required
  - b) May use available farm labor
  - c) Lower efficiency
- **Dealer**
  - a) Single responsible party
  - b) Crews (subs) experienced in working together
  - c) Dealer reputation is important

H. Comparing bids

- **Key items of comparison**
  - **Design tolerance. What is the uniformity of water delivered in the field.**
    - ***Typically all these being even, higher efficiency will cost more than low efficiency. You may end up paying less for a non-uniform system. Many times the life cycle cost of a system is higher.***
  - **Total Dynamic Head (TDH). What is the horsepower required to operated the system.**
    - ***This relates to the size of motor or engine required to satisfy the system hydraulics. Usually, a system with a higher TDH requirement will be the system most costly to operate.***

H. Comparing bids

- **Key items of comparison (con't)**
  - **Are the application rates and duration of irrigation times similar?**
    - ***Are the application rates less or equal to the infiltration rate of the soil. If not, run-off will occur. Does the irrigation duration during peak ETo allow for catch-up and down time? If not, you run the risk of water deficit.***

I. Verifying Performance

- **Does the system perform as stated?**
  - **Hopefully your contract identified an “Emission Uniformity” to be verified in by a field audit at system start-up**
    - ***Emission Uniformity calculation can be applied to an entire drip system, a system sub-unit, or an individual lateral. When data is collected in a newly installed system, it represents the effects of both the manufacturing variability and pressure differences (elevation changes and/or piping losses) within the drip system. In older systems, flow rates can also be affected by emitter clogging.***

I. Verifying Performance

- **Emission Uniformity (EU)**

  EU measures the uniformity of flow rates from emitters.

  EU is calculated according to the formula:

  $$EU = 100 \left(\frac{L}{Q_{ave}} \right)$$

  where

  ***EU** is Emission Uniformity (%)*

  ***L** is the average flow rate in the Low Quarter*

  ***Low Quarter** is the 25% of the emitters w/lowest flow rate*

  ***Q_{ave}** is the average flow rate for the sample*

I. Verifying Performance

- EU rating per ASAE EP458 Dec 93 (withdrawn)

  Field evaluation of Micro-irrigation systems

Acceptability	EU
Excellent	100-94
Good	87-81
Fair	75-68
Poor	62-56
Unacceptable	< 50

J. Conclusions

- **Setting the conditions of your irrigation system**
  - a) Decide how you want to purchase your irrigation system
  - b) Be sure competing bids meet the needs of crop/practices
  - c) Be sure you are comparing “apples to apples”
  - d) Specify system performance in the contract and verify with field measurements at system “start-up”


Questions???
Thank You !