Design of EPC Drip Irrigation System

It is necessary to design a suitable and economically viable system to deliver a predefined amount of water at the root zone of each plant at regular intervals. This is to ensure that the plants do not suffer from stress or strain of less and over watering. Totally customized, efficient and long-life system ensures saving in water, early maturity and a bountiful harvest, season after season, year after year. Apart from all this, savings in labour and fertilizer costs.

Prime objectives of design should be,

1. To achieve higher water application and conveyance efficiency.
2. To optimize both initial as well as operation cost.
3. To design the system for long term and high performance.
4. To satisfy and fulfillments and requirements of the farmer.

Design Inputs:

In order to achieve higher accuracy level in application of water to each and every plant, detailed survey is necessary. Detailed study of the following inputs is required for effective utilization of available resources.

- Assessment of water source and availability of water, electricity etc.
- Agronomical details like crop, spacing, age, peak water requirement, row direction for row crops etc.
- Climatic data such as temperature, humidity, rainfall, evaporation etc.
- Details about soil type, water quality etc with Soil and Water analysis reports.
- Details of any existing resources like pump, main line etc.

Design criterion for EPC drip irrigation system:

Effective design should be reflected in its operation as far as flow variation is concerned. There should be minimum variation in emission of drippers. Overall irrigation efficiency should be more than 90 %.

Steps in designing EPC drip irrigation system:

The design of drip irrigation differs from crop to crop, plot to plot, soil to soil and climatic conditions. In general, following steps are involved in design of EPC drip irrigation system.

1. Obtaining site information
2. Calculation of water requirement
3. Selection of drippers and calculation of irrigation time
4. Selection and design of lateral
5. Selection and design of submain line
6. Selection and design of main line
7. Selection of pump

1. **Obtaining site information**: Obtaining site information is a very important step in the design procedure. Complete and accurate survey with other field information is essential for designing an efficient irrigation system.

2. **Calculation of water requirement:** While designing the EPC drip irrigation system, highest water required for the plant throughout its lifecycle is considered for calculation of water requirement. While calculating peak water requirement, peak rate of evapo-transpiration is taken into consideration. For peak water requirement for various crops please refer Annexure I. Please note that peak water requirements mentioned in Annexure-I are only for reference, actual water requirement may vary depending upon soil type, agro-climatic conditions, crop variety etc.

3. **Selection of drippers and calculation of irrigation time**: Selection of drippers should be based on water requirement, soil type, water availability, electricity availability etc. Drippers should be selected such that it should emit enough water to fulfill water requirement within predefined time.

4. **Selection and design of lateral:** Design of lateral should be based on maximum 7.5 - 10% discharge variation and up to 15% pressure variation. Laterals are available in various sizes of 12 mm, 16 mm, 20 mm etc. Calculate the average dripper spacing on laterals. e.g. if for any orchard crop having spacing 8 m x 8 m, we are providing 4 Kimneer drippers of 8 LPH per plant, then average dripper spacing will be 8 m / 4 drippers, i.e. 2 Mtr. Then refer Annexure-II, for average dripper spacing of 2 m and for 8 LPH, 16 mm lateral can be laid up to 83 m and 12 mm lateral can be laid up to 49 m. For maximum lateral running length please refer Annexure-II. Design the layout of the system considering maximum lateral running length so as to obtain higher uniformity.

5. **Selection and design of Submain**: After finalizing drippers and laterals or in-lines, we have to decide the no of sections, for the entire area, so that irrigation cycle can be completed in the available time for operation. Design of submain for the particular section is based on both capacity and uniformity. Submain size should be large enough to deliver the required amount of water to irrigate subsequent part of the field. Calculate the discharge for the respective section, and by referring Annexure-II, decide the size of the submain. The size of the submain is optimized at maximum 2 m head loss.

6. **Selection and design of mainline**: After finalizing drippers, laterals/in-lines and submain sizes and locations, we have to connect all the submains to the water source using the main line. Size of mainline is decided by considering the quantity of water flowing through it. It's very important to decide how many submains are to be operated at one time, and based on that the flow through the mainline is calculated and size of mainline is designed for that flow using Annexure-II.

7. **Selection of Pump**: Size of pump depends upon the flow of water required and total pressure required at the pump to operate the irrigation system efficiently. While designing the system from drippers to mainline, we have finalized the system flow (Q). The pump should have the capacity to deliver this flow. The required total head (H) of pump is the sum of all following heads,

   a) Operating Pressure (considered 1 Kg/cm^2, i.e. 10 m),
   b) Head loss in laterals (considered 2 m),
   c) Head loss in submains (considered 2 m),
   d) Head loss in main line,
   e) Head loss in fittings,
   f) Head loss in filters,
   g) Head loss in venturi (if used very frequently),
   h) Head loss in NRV,
   i) Static head of the field,
   j) Pump suction and delivery head.

   Now our flow (discharge) and total head of pump is finalized. We can calculate the approximate HP of pump using following formula,

$$Pump\ \ Hp = \frac{Q\ \ in\ \ LPS\ \ X\ \ H\ \ in\ \ Mtr}{45}$$

Model Design of 1.44 ha row crop

Crop:	Vegetables
Row to row spacing:	5 feet (1.52 m)
Dripper spacing:	0.4 m (Inline)
Size of land:	1.44 ha (120 m X 120 m)
Land slope:	0%
Water source:	Well, at the corner of the field.
Discharge Available:	16000 LPH
Depth of water source:	8 mtr
Electricity availability:	8 hrs /day

1. **Crop water requirement**:

Referring to Annexure-I, water requirement of vegetables for 5 feet row to row spacing is 12 litre/mtr/day. This is water required for per meter length of row. Hence total water required per day for 1.44 ha area is,

Total Water required/day = Total length of rows (mtr) X Water requirement (lit/mtr/day).
Here, total length of rows = 120 x 120/1.52 = 9474 mtr
Water required for whole field/day= 9474 X 12 = 113688 liters per day (Say 114 M^3)

2. **Selection of In-line and calculation of irrigation time**:
Suppose we are using inline of 16 mm x 2 LPH x 0.40 mtr.
Irrigation Rate of this lateral is 2 LPH @ 0.40 Mtr i.e. 5 LPH per Mtr
Peak water requirement is 12 Lit per Mtr per Day as per Annexure-I

$$Irrigation\ \ Time\ \ (Hrs) = \frac{Water\ \mathrm{Re}quirement\ \ (lit/mtr/day)}{Irrigation\ \ Rate\ \ (lit/hr)} = \frac{12}{5} = 2.4\ Hrs\ per\ day$$

i. e. irrigation system should be operated for 2 Hrs 24 Min per section to fulfill the water requirement.
Now since we have electricity available for 8 hrs per day, we can make 8/2.4 = 3.33 i.e. maximum 3 Sections.
Total length of lateral reqd = Total area (Sq. Mtr.) / Row Spacing (Mtr) = 14400/1.52 = 9474 Mtr
Total discharge required = 9474 mtr X 2 LPH / 0.4 mtr = 47370 LPH
Now, available pump discharge is 16000 LPH, we can make 47370/16000 = 2.96 i.e. minimum 3 Sections.
Now, Refer Annexure-II, in this case, maximum in-line lateral running length for 16 mm x 2 LPH x 0.40 Mtr is 82 m. Head loss in laterals is 2 mtr.
Divide the field in to 3 sections based on maximum lateral running length, electricity availability and available pump discharge.

3. **Design of Submain**:
For design of submain refer Annexure-II.
Discharge of each submain= 47370/3= 15790 LPH = 4.39 LPS.
Referring to Annexure-II, for the discharge of 4.39 LPS, suitable size of submain is 63 mm, 4 KSC. Total head loss in submain is 2 mtr.
Total Length of submain required is 120 mtr. 3 submains of 40 mtr each are placed at the centre of the field and laterals are laid along both sides of the submain, for 60 mtr lengths.

4. **Design of mainline:**
For design of main refer Annexure-II. Here one submain is operated at one time. Hence discharge through mainline is same as the discharge through a submain i. e. 4.39 LPS. Referring to Annexure-II, we see that 75 mm size of pipe is suitable to carry the flow.
Head loss at maximum discharge i. e 5 LPS through 75 mm PVC pipe is 22.6 m. but we have lesser discharge in this case. For calculating actual head loss, refer Annexure-III. We find that for 75 mm pipe and for 4.39 LPS flow, head loss is 18 m for 1000 m length of pipe. Here, total length of mainline is 140 m.
Hence head loss through 75 mm pipe of 140 mtr length at 4.39 LPS is = 18 x 140/1000 = 2.52 mtr

5. **Design of Pump:**
Required discharge of pump is 4.39 LPS. Now we have to calculate total head of pump. Consider head loss from dripper to pump foot valve (i.e. water source).

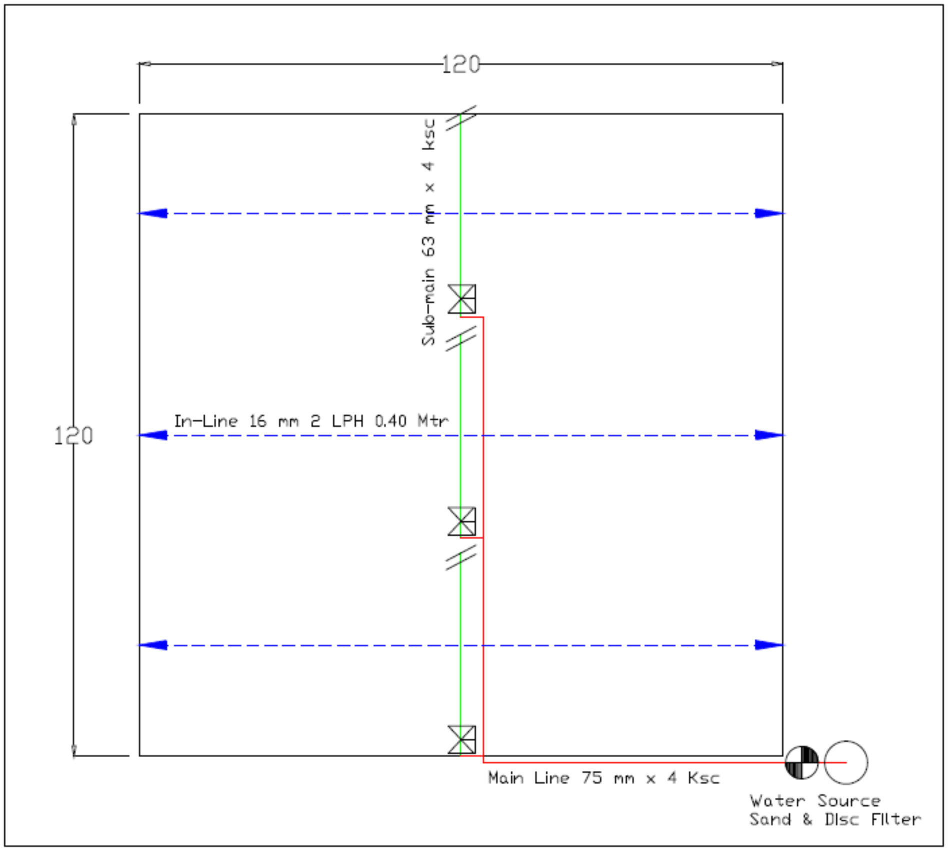
a. Operating Pressure: 10 m
b. Head loss in laterals: 2 m
c. Head loss in submains: 2 m
d. Head loss in main line: 2.52 m
e. Head loss in fittings(Approx.): 2 m
f. Head loss in sand filter: 5 m
g. Head loss in disc filter: 3 m
h. Head loss in NRV: 1 m
i. Static head of the field: 0 m
j. Pump suction and delivery: 8 m

Total head: **35.52 m (Say 36 Mtr),**

Pump should give discharge of 4.39 LPS at 36 Mtr Head.

$$Approximate\ \ Pump\ \ Hp\ = \frac{Q\ \ in\ \ LPS\ \ \ X\ \ \ H\ \ in\ \ Mtr}{45} = \frac{4.39\ \ X\ \ 36}{45} = 3.51\ \ HP$$

Model Design layout of the field 1.44 ha



Operation Schedule for 1.44 Ha model Vegetable plot

Sr. No.	Section No.	Discharge	Peak Operation Time	Area Covered	Total Volume of Water Required
1	1	15804 LPH	2 hrs 24 min	0.48 Ha	37930 Lit
2	2	15804 LPH	2 hrs 24 min	0.48 Ha	37930 Lit
3	3	15804 LPH	2 hrs 24 min	0.48 Ha	37930 Lit
			7 hrs 12 min	**1.44 Ha**	**113790 Lit**

Annexure-I: Peak Water Requirement of different Crops

Sr. No.	Crop	Spacing (Ft X Ft)	Peak Water Requirement
1	Grapes	6 x 4	10 – 12 Ltr/Day/Plant
		8 x 6	18 – 20 Ltr/Day/Plant
		8 x 8	24 Ltr/Day/Plant
		8 x 10	30 Ltr/Day/Plant
2	Pomegranate	10 x 10	30 – 40 Ltr/Day/Plant
		12 x 12	40 – 50 Ltr/Day/Plant
		15 x 15	70 – 75 Ltr/Day/Plant
3	Guava	15 x 15	70 – 80 Ltr/Day/Plant
		18 x 18	100 – 120 Ltr/Day/Plant
		25 x 25	120 – 130 Ltr/Day/Plant
4	Mango	25 x 25	120 – 140 Ltr/Day/Plant
		30 x 30	150 – 170 Ltr/Day/Plant
5	Sapota / Chiku	25 x 25	120 – 140 Ltr/Day/Plant
		30 x 30	150 – 170 Ltr/Day/Plant
6	Orange / Lemon / Citrus	16 x 16	75 Ltr/Day/Plant
		18 x 18	85 Ltr/Day/Plant
7	Custard Apple	10 x 10	40 Ltr/Day/Plant
		12 x 12	50 Ltr/Day/Plant
8	Ber	10 x 10	30 Ltr/Day/Plant
		12 x 12	55 Ltr/Day/Plant
9	Banana	6 x 4	22 Ltr/Day/Plant
		6 x 6	25 Ltr/Day/Plant
		5 x 5	22 Ltr/Day/Plant
		3 x 6 x 5	25 Ltr/Day/Plant
10	Papaya	5 x 4	18 Ltr/Day/Plant
		7 x 7	20 Ltr/Day/Plant
11	Coconut	25 x 25	90 Ltr/Day/Plant
12	Cardamom	10 x 10	15 Ltr/Day/Plant
13	Rubber	15 x 15	24 Ltr/Day/Plant
14	Oil Palm	30 x 23	150 Ltr/Day/Plant
15	Sugarcane	Lateral to Lateral 8 Feet	20 Lit/Mtr/Day
		Lateral to Lateral 7 Feet	18 Lit/Mtr/Day
		Lateral to Lateral 6 Feet	16 Lit/Mtr/Day
		Lateral to Lateral 5 Feet	14 Lit/Mtr/Day
16	Cotton	Lateral to Lateral 6 Feet	15 Lit/Mtr/Day
17	Vegetables / Flowers	Lateral to Lateral 6 Feet	14 Lit/Mtr/Day
		Lateral to Lateral 5 Feet	12 Lit/Mtr/Day
		Lateral to Lateral 4 Feet	10 Lit/Mtr/Day
18	Tea / Coffee	Lateral to Lateral 8 Feet	15 Lit/Mtr/Day
		Lateral to Lateral 7 Feet	13 Lit/Mtr/Day

Note:

Above water requirements are indicative. Actual water requirements can change according to actual evaporation, soil type and climatic conditions.

Annexure-II

A) Maximum Lateral Running Length (Mtr) with On-line drippers at 7.5 % discharge variation on flat ground (HL 2 Mtr)

Average Dripper Spacing (m)	2 LPH				4 LPH				8 LPH				16 LPH			
	12 mm		16 mm		12 mm		16 mm		12 mm		16 mm		12 mm		16 mm	
S	L	N	L	N	L	N	L	N	L	N	L	N	L	N	L	N
0.3	35	117	59	197	17	57	29	97	14	47	24	80	-	0	-	0
0.4	43	108	71	178	21	53	35	88	17	43	29	73	-	0	-	0
0.5	49	98	83	166	24	48	41	82	20	40	33	66	-	0	-	0
0.6	56	93	93	155	28	47	46	77	22	37	38	63	-	0	-	0
0.75	64	85	108	144	32	43	54	72	26	35	43	57	-	0	-	0
0.9	73	81	121	134	36	40	60	67	29	32	49	54	-	0	-	0
1	78	78	130	130	39	39	65	65	31	31	52	52	-	0	-	0
1.25	90	72	150	120	45	36	75	60	36	29	61	49	22	18	39	31
1.5	101	67	169	113	50	33	84	56	41	27	68	45	25	17	43	29
1.8	114	63	190	106	57	32	95	53	46	26	77	43	27	15	50	28
2	122	61	204	102	61	31	102	51	49	25	83	42	30	15	52	26
2.5	141	56	236	94	70	28	118	47	57	23	96	38	36	14	65	26

B) Maximum In-line Lateral Running Length (Mtr) with 7.5 % Discharge Variation on Flat Ground (Head Loss 2 Mtr)

Dripper Spacing (m)	2 LPH				4 LPH			
	12 mm		16 mm		12 mm		16 mm	
S	L	N	L	N	L	N	L	N
0.3	41	137	68	227	26	87	43	143
0.4	49	123	82	205	31	78	52	130
0.5	57	114	95	190	36	72	61	122
0.6	64	107	107	178	41	68	68	113
0.75	74	99	124	165	47	63	79	105
0.9	83	92	140	156	53	59	89	99
1	89	89	149	149	57	57	95	95
1.25	103	82	173	138	66	53	110	88
1.5	116	77	195	130	74	49	124	83

C) PVC Main Line Flows

Size	Flow LPS	HL at Max. Flow
40 mm x 6 Ksc	up to 1	30 m/1000 m
50 mm x 6 Ksc	1 to 1.8	30 m/1000 m
63 mm x 4 Ksc	1.8 to 3	22 m/1000 m
75 mm x 4 Ksc	3 to 5	22.6 m/1000 m
90 mm x 4 Ksc	5 to 8	23 m/1000 m
110 mm x 4 Ksc	8 to 11	15 m/1000 m
125 mm x 4 Ksc	11 to 16	16 m/1000 m
140 mm x 4 Ksc	16 to 20	14 m/1000 m
160 mm x 4 Ksc	20 to 24	12.5 m/1000 m
180 mm x 4 Ksc	24 to 32	10.7 m/1000 m
200 mm x 4 Ksc	32 to 41	9.5 m/1000 m

D) Head Losses through Different Components

Lateral	2 m
Submain	2 m
NRV	1 m
Hydrocyclone Filter	5 m
Sand Filter	5 m

Disc Filter	3 m
Screen Filter	2 m
Venturi /F. Tank	5 m
PVC Fittings (Approx)	3 m

E) PVC Sub Main Flows

Size	Max Flow	HL
40 mm 6 Ksc	Up to 1.8 Lps	2 m
50 mm 6 ksc	1.8 to 3 Lps	2 m
63 mm 4 ksc	3 to 5 Lps	2 m
75 mm 4 ksc	5 to 8 Lps	2 m

Annexure-III : Head Loss in PVC Pipes (M/1000 Mtr)

Flow LPS	PVC Pipe Outer Dia and Pressure Rating							
	40 mm x 6 Kg/Cm^2	50 mm x 6 Kg/Cm^2	63 mm x 4 Kg/Cm^2	75 mm x 4 Kg/Cm^2	90 mm x 4 Kg/Cm^2	110 mm x 4 Kg/Cm^2	125 mm x 4 Kg/Cm^2	140 mm x 4 Kg/Cm^2
0.5	**9.0**	3.2						
0.6	**12.0**	4.4						
0.7	**16.0**	5.5						
0.8	**20.0**	7.2						
0.9	**25.0**	9.0						
1.0	**30.0**	10.8						
1.1	36.0	**13.0**						
1.2	42.0	**15.0**						
1.3	48.0	**17.0**						
1.4	57.0	**19.5**						
1.5		**22.0**	6.0					
1.6		**24.5**	7.0					
1.7		**27.0**	8.0					
1.8		**30.0**	9.0					
1.9		33.0	**10.0**					
2.0		36.0	**11.0**					
2.2		42.0	**12.0**					
2.4		50.0	**14.0**					
2.6		57.5	**16.5**					
2.8			**19.0**	8.0				
3.0			**22.0**	9.0				
3.2			24.5	**10.5**				
3.4			27.0	**11.5**				
3.6			29.0	**12.5**				
3.8			32.0	**14.0**				
4.0			35.0	**15.0**	6.5			
4.2			38.5	**16.5**	7.3			
4.4			42.0	**18.0**	8.0			
4.6			45.5	**19.5**	8.6			
4.8			49.0	**21.0**	9.2			
5.0			52.5	**22.6**	9.7			
5.5				27.0	**12.0**	4.4		
6.0				32.0	**14.0**	5.0		
6.5				37.0	**16.0**	5.8		
7.0				41.0	**18.0**	6.7		
7.5					**20.2**	7.5		
8.0					**23.0**	8.5		
8.5					24.0	**9.5**		
9.0					25.0	**10.5**		
9.5					28.2	**11.6**		
10.0					32.0	**12.8**		
11.0					40.0	**15.0**	8.0	
12.0						17.3	**9.0**	
13.0						20.0	**10.5**	
14.0						22.5	**12.0**	
15.0						25.0	**14.0**	
16.0							**16.0**	9.5
17.0							17.0	**10.5**
18.0							18.5	**11.5**
19.0							20.0	**12.8**
20.0							23.0	**14.0**

…..Thank You